POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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affiliated

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A Matter of Impulse—

THAT'S WHAT old Rastus told the judge when the latter questioned him regarding his visit to a certain neighborhood chicken coop the evening before. "Yassuh, yoh honah, yassuh, it wuz jes a mattah uv impulse, das all."

And so it is with lightning — just a matter of impulse, but what an impulse. Oh Boy! Of course, we might have suspected this ever since Ben Franklin flew his kite in a thunderstorm, but it was not until only the last decade when engineers began to deal with lightning in a scientific way that its impulse nature became to be fully appreciated. The fact was, nobody had ever actually measured or recorded a lightning stroke and nobody had any idea as to what its form or wave shape was like. But along about 1925 electrical engineers were getting quite cocky—they had done some pretty clever jobs in the years preceding and as lightning effects were becoming more destructive as transmission lines increased they decided to tackle old man lightning himself. Armed with oscillographs and klydonographs, they girded themselves and set out to trap him.

They succeeded. How well is amply recorded in the transactions of the American Institute of Electrical Engineers. The whole thing began in the year of many storms as the Chinese would say; the year made memorable by the Shenandoah disaster—but wait, we're not going to tell you about it here. We'll let Everett Lee tell you about it in his article on the Romance of Lightning Research on page 390. Mr. Lee tells the story much better than we could, for he is one of those born romancers of whom we see only too few in the engineering professions. We feel sure you'll like it.

Now, let's see, there was something else on our mind. Oh, yes, in looking over the contents of this issue we noticed an article on Gang Bonus Systems. Now, it seemed to us that this was going too far. We're strong for efficiency and we have preached bonus systems in the power plant, but to put "gangs" on a bonus basis, well, it didn't seem quite the proper thing to discuss in a magazine of reputable character. We immediately began to point out that gangs operated quite well without bonus systems and cited the St. Valentine Day Massacre in Chicago, as well as Legs Diamond's achievements before he himself was bumped off. Imagine, we said, a good machine gun crew in the liquor racket neglecting the finer points of their technique merely in an effort to run up a high monthly average. Quality we insisted was always preferable to quantity. But in all this discussion we are glad to admit we were all wrong. Upon reading the article we found it dealt with an entirely different type of gang than we assumed. It seems this is the power plant gang and the idea of the bonus is not only to get better economy but to establish better coöperation among the members of the gang.

At the Denver Tramway Co. where it is used, the coal consumption dropped from 5 to 2½ lb. per kw-hr. when it was put into effect. Read the article on it on page 383—it may give you some new ideas.

Another article we direct your attention to is the one by H. M. French on Exciters. You may not realize it, but there have been many interesting developments in exciters recently. We found that out when we first took a ride on the "Cyclone" at the Century of Progress. This type of exciter has nothing to do with the exciters which Mr. French tells about. This article deals with the type of exciters found in power plants, particularly those furnishing direct current to the fields of synchronous motors and synchronous condensers. Modern synchronous motor controllers provide automatic means for applying and removing excitation at proper times. New relays give increased flexibility in this respect.

Have you got a code? If you haven't you'd better get one for if you don't you will have the NRA on your trail before long. On page 394 we present the code which the electrical industry got up. Offhand it looks like a perfectly good code but some of the utility companies don't seem to think so—a couple of them said "We won't sign it" and promptly resigned. The trouble it seems is not so much with the code but with the attitude of certain of the public utility commissions. They, it seems, are always gumming up the works. Well, maybe Johnson will get after 'em, who knows?

WITH THE EDITORS

We Do Our Part

ON THE CONTENTS page of this issue, Power Plant Engineering displays the emblem of membership in the National Recovery Administration's drive for better business, having promptly signed and complied in every way with the code for periodical publishers. The code is reasonable in all respects and is in harmony with justice in business affairs. Strict, voluntary adherence to the provisions of the code in all industries, we believe, will have a decidedly beneficial result on the social order of the country. This emblem will hereafter be displayed on the same page in each issue of Power Plant Engineering.

Low Temperature Radiation and Reversed Refrigeration

THERE IS a growing interest these days in the question of low temperature radiant heating, particularly in connection with electric heating. It is claimed that low temperature radiant heating in combination with reversed refrigeration would so lower the operating cost of electric heating as to make it competitive with heating by other fuels. Whether this can be proved commercially or not, the fact remains that heating by low temperature radiation is an interesting thing and it is strange that its general application has been delayed so long. In England, it is true, examples of this form of heating have been in use for many years but the application has never become general.

With regard to electric heating by this method, it is of interest to know that in England recently a type of wall paper has been produced with a fine electric resistance element woven into it. When placed on the walls of rooms this heating element is connected to the electricity supply mains so as to heat the walls to a low temperature for radiant heating.

The theory underlying this form of heating is sound. The idea is to supply heat to the body by direct radiation at such a rate as to maintain comfort even though the surrounding air is comparatively cool.

Until quite recently, the importance of low temperature radiation was not fully appreciated. It was known that the average human body engaged in ordinary sedentary occupation liberated an appreciable quantity of heat. Theater plant operators and others having to do with the heating or cooling of halls containing large audiences know this only too well for the heat liberation of an audience of two or three thousand people is of considerable magnitude and must be taken into account in the operation of heating or cooling systems.

Tests at the research laboratories of the American Society of Heating and Ventilating Engineers shows that the average person loses heat at the rate of 400 B.t.u. per hour. This heat is dissipated by radiation, convection, and moisture evaporation from the skin. Of the total amount dissipated it has been found that in ordinary winter conditions, indoors, 46 per cent is lost by direct radiation, 30 per cent is convected and only 24 per cent disappears as latent heat of evaporation.

These figures indicate to some degree the possibilities of direct low temperature radiation from room surfaces, for if radiation is so effective a means of removing heat from a person's body, it should also be an effective method of supplying heat to the body and of restoring the balance between the heat generated in the body and its dissipation.

Experience with this type of heating, it seems, has been quite satisfactory and when carefully designed such systems produce comfortable and economical results. Unquestionably this form of heating is destined to find increasing application and if used in connection with the reversed cycle of refrigeration, it may bring about a greatly increased use of electricity. By pumping heat from the outside to a moderate temperature of say 80 deg. F. and with one cent power, the actual costs, it is claimed, become competitive with coal.

This type of heating system has other advantages besides comfort and economy of operation. The entire absence of radiators as such simplifies the matter of arrangement and decoration in homes and offices, a fact which should aid in no small measure in increasing its popularity.

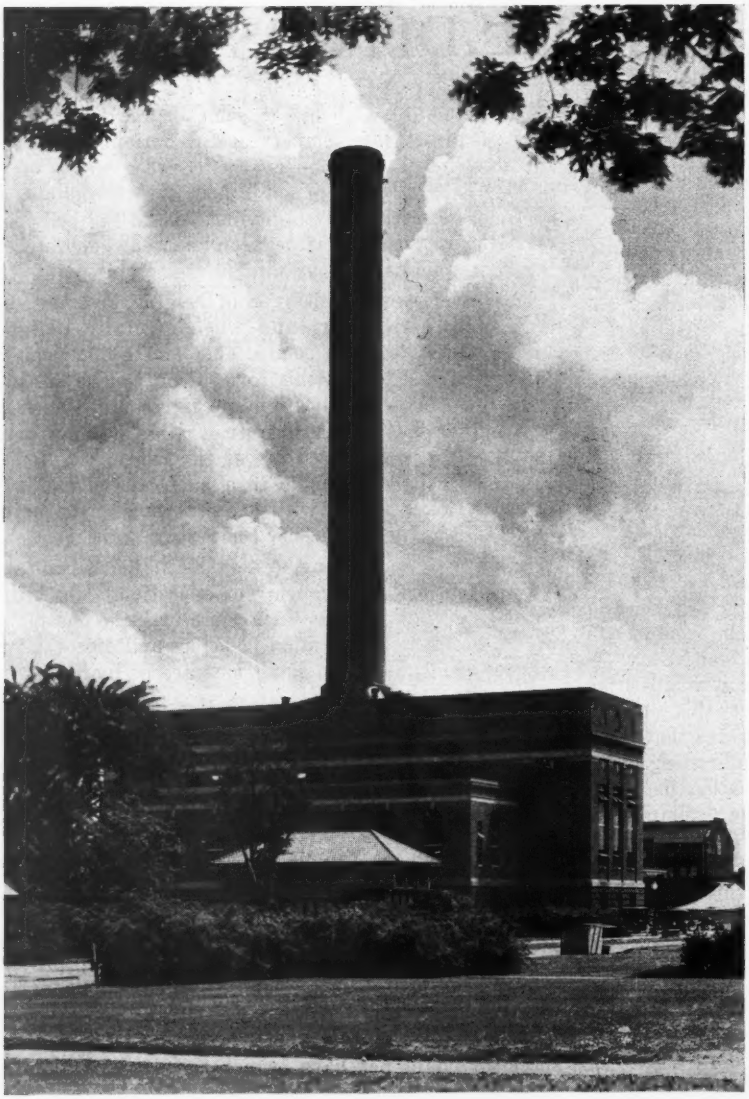
New Responsibility for American Standards Association

ANNOUNCEMENT WAS made recently that the U. S. Bureau of Standards will discontinue certain specified practice and industrial standardization activities and will turn this work over to the American Standards Association. This association is supported by 37 national technical societies, trade associations and government bodies and if, in the interest of economy in government, the Department of Commerce was forced to abandon this important activity, its selection of a successor could not have been better made.

Industrial concerns, however, are not the principal beneficiaries of the standardization movement, for there is not a standardized product manufactured that is not less expensive in first cost and repair than a similar product made of unstandardized parts. For example, a certain toaster has a specially designed plug connection that has a way of burning out quite frequently, the cost to replace it is three or four times that of a standard plug and the repair part can be secured only from specific dealers who frequently must send to the factory for it, causing considerable delay. Thousands of examples of this sort could be cited where the public in general benefits by standardization. It has been estimated that in the lumber industry alone $200,000,000 have been saved by the adoption of standards recommended by the Bureau of Standards, much of this saving is, by force of competition, passed on to the public.

With the American Standards Association taking over this work it is hoped that the interests of the ultimate consumer will not be forgotten even though the financial support of the Association's work must come, in great measure, from industrial concerns.

Purdue's N



BECAUSE of the universal and insistent demands to trim expenses, reduction of power and heating costs is always a subject of vital interest. Where large quantities of process steam can be used or where a power interchange agreement can be made with a utility system, high pressure bleeder or even straight back pressure turbines can usually be depended upon for worth while savings. These conditions do not always exist, however, thousands of institutions and small industries having no process steam load but a considerable and variable heating and electric load. In the summer the steam heating load disappears and even in the winter, the electric and steam heating peaks, coming at different hours, are difficult to handle in a way that will take advantage of the economies offered by modern power plant equipment.

Such problems are not impossible of solution, however, and the new 2500-kw. section of the Purdue University power plant is an excellent example of a type of plant that will undoubtedly be widely used in institutional and small industrial plants during the next few years. High pressure boilers supply steam to a condensing bleeder turbine from which the entire throttle flow can be bled to feed the heating system.

Most interesting, however, is the fact that this plant is so operated that steam is produced at a cost of $0.271 per 1000 lb.; power for $0.0115 per kw-hr. and pumping water for $0.033 per thousand gallons. These costs, averaged for the year of 1932, are total costs including all operating and fixed charges except interest on the investment (not allowed by state regulation). Details of these costs over a period of years are shown by Figs. 6 and 8.

Increased unit costs since 1930 are caused by increased fixed charges, due to building extensions and new equipment. For instance, the water works investment increased from $13,087.22 in 1930 to $55,389.83 in 1932. Increased pumpage, necessary for projected buildings, can be taken care of without increased fixed charges or, due to pump characteristics, any appreciable increase in operating charges. Pumping costs will be about halved when up to the designed capacity. Similarly the power plant building as completed will take care of two more boilers and another 2500-kw. turbine. Total costs of the completed plant, estimated from costs of the last addition are shown by Fig. 5B.

The first section of the plant built in 1925 consisted of four 2500 lb., 5000 sq. ft., Stirling bent tube boilers, with a furnace volume of 2110 cu. ft. and fired by Taylor underfeed stokers with a projected grate area of 102.9 sq. ft. each. Coal received by rail is dumped to a track hopper, crushed and elevated to a bunker by means of a peck carrier. Generating equipment consists of two 500-kw., 3 ph., 60 cycle, 0.8 p.f., General Electric 190 lb. ga. 100 deg. sup. turbo-generators designed to operate either condensing or non-condensing. Each turbine is set over a 942 sq. ft. Worthington condenser. Two of the boilers have 547.6 sq. ft. superheaters. There were two Green Fuel Economizer Co. forced draft fans each

's New Power Plant Extension *Reduces* Cost of Operation

By L. D. McCOY
Engineering Dept., Physical Plant, Purdue Univ.

PURDUE University, one of the country's leading Engineering colleges, utilizes modern power plant equipment in a type of plant which should interest those having charge of institutions and small industries. ¶ The first section of this plant was built in 1925 and was described in Power Plant Engineering for September 1 of that year. Now, this plant has been extended and with the installation of the most modern and suitable type of equipment costs of steam, water, and power have been reduced to a remarkable extent.

driven by 1186 r.p.m., 120 hp., Terry non-condensing steam turbines and rated at 60,000 c.f.m. at 7 in. of water.

Ash handled by industrial car is dumped in a quenching pit and later removed by a locomotive crane with a grab bucket. The brick stack, 250 ft. high, 15 ft. inside diameter, is between the old and new boiler sections directly in line with the ash hoppers, which on the new boilers equipped with clinker grinders were too low to allow passage of the industrial cars. Ash from the new boilers discharge to a peck carrier which passes through the base of the stack and discharges to the small cars. Full load turbine water rates are 17.25 lb. per kw-hr. condensing and 36.3 lb. non condensing.

The two new boilers are 6448 sq. ft. 200 lb. pressure Stirling equipped with 960 sq. ft. of convection superheater surface and set over a 2690 cu. ft. furnace with 185 sq. ft. of cast-iron block water cooled surface divided between the side and back walls, the front walls being air cooled. Each boiler is fired by a 5 retort, 37 tuyere Taylor stoker with a projected grate area of 144.2 sq. ft. similar to the original stoker except that a direct connected Terry turbine drive was substituted for the steam engine. Steaming capacity of the new boilers is 28,160 lb. per hr. normal and 44,740 lb. maximum. Both boilers are served by a 64,000 c.f.m. (at 7 in. water) forced draft fan driven by a 110-hp., 1180 r.p.m. turbine, or in combination with old equipment.

In the turbine room the new or third unit consists of a 2500-kw. 3600 r.p.m., 190 lb. 150 deg. F. superheat Westinghouse bleeder condensing turbine set over a 2530 sq. ft. Foster Wheeler condenser and driving a 3140 kv-a., 2300 v., 0.8 p.f., 3 ph., 60 cycle generator. Operating condensing with a 3 in. vacuum, the bleeder pressure is 10 lb. ga.; operating non-condensing and using the bleeder, the pressure can be varied at a predetermined point from 5 to 15 lb. ga. Full load water rate condensing is 13.6 lb. per kw-hr., non-condensing 29.6 lb. per kw-hr. or for a maximum extraction of 69,000 lb. per hr., 28.8 lb. per kw-hr. Cooling water is supplied from a spray pond by

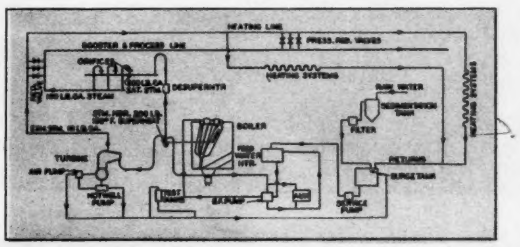


FIG. 1. FLOW DIAGRAM OF THE NEW SECTION OF THE PLANT

a 12 in., 4350 g.p.m., 50.5 ft. head single stage Foster Wheeler centrifugal pump driven by a 75-hp., 1160 r.p.m. induction motor. The air pump is a 10 c.f.m. twin 2 stg. steam jet.

Feedwater makeup is treated by a 3200 g.p.h. Cochrane hot process softener and the feedwater is heated by two Cochrane metering deaerating heaters working in parallel, one installed with the first section of the plant and one with the second. Condensate from the heating system is collected in a 10 ft. by 10 ft. 6 in. by 20 ft. surge tank in the boiler room basement. The plant is completely equipped with flow meters, draft gages, CO_2 meters, pressure gages and soot blowers. At present 4th or 5th vein Indiana screenings, having heat content of from 10,000 to 13,000 B.t.u. per lb., are being burned. Another thing of interest is that this plant is completely equipped with thermometer wells, calorimeter connections and measuring tanks, so that a test can be run on the plant without any loss of time or energy wasted in getting ready. Senior engineering students have definite schedules worked out so that each has a certain duty in a complete uninterrupted 8 hour test in the heating and power plant and which is done under capable supervision.

WATERWORKS

During the year preceding the actual construction of the second unit of the plant an initial move was made toward establishment of an independent water plant. Four 12 in. wells averaging approximately 200 ft. deep were drilled in such positions that they are now enclosed by the building. Three of these wells are now being pumped by means of 750 g.p.m. Worthington Coniflo

FIG. 2. NEW BOILERS FROM THE FIRING FLOOR

deep well pumps driven by 75-hp., 1750 r.p.m., 3 ph., 60 cycle, 2300 v., vertical motors. The present installation includes three motor driven and one steam turbine driven 750 g.p.m., 1750 r.p.m. horizontal single stage centrifugal pumps and one steam turbine driven fire pump. The booster pumps, with a positive suction head of 60 ft., discharge against a pressure of 60 lb. per sq. in. when operated individually, although the piping is arranged and valved in such a way that any of the booster pumps can be used separately or combined. Any three of these pumps operating in series will produce a discharge pressure of 130 lb. per sq. in. gage to be used on the mains and fire risers in the buildings when some of the present lines can be replaced or improved to carry that pressure. The service lines of the buildings will be reduced to approximately the present pressure. The fire pump has a capacity of 1750 g.p.m. at a 90 lb. per sq. in. discharge pressure and a speed of 2300 r.p.m. In addition to the above pumping equipment there is an electrically welded steel water storage tank covered with 2 in. cork insulation and located in the addition similarly to that of the coal bunker in the first unit. This storage tank is cylindrical in shape having semi-spherical ends and is 16 ft. in diameter and 80 ft. long with a capacity of 110,000 gal. The arrangement is such that only one-half can be drawn from the tank by the booster pumps for the ordinary service, leaving the other half at all times as a reserve for fire service. A manually propelled 4 t. crane with motor operated hoist is available for use in either the generating room or pump room.

Piping

All of the piping both in the steam and water portions of the plant above 2 in. in size is a steel welded job using pipe bends to care for expansion. The flanges used at valves are of the VanStone type and wherever possible in the addition welding fittings were used instead of the customary cast flanged fittings.

Building

Since the plant was to be located in a conspicuous part of the Campus, it was necessary to construct a building of suitable materials to harmonize with other buildings. The architecture follows the lines of utility, having been adapted to the needs of a structure of this character. The building was built in units, the size of which were determined by the immediate requirements for equipment. Inasmuch as the design included one central stack to care for the demands of the completed plant and since one half of the ultimate would care for the near future, enough more than half of the building to enclose the stack, was erected, and equipped as the first unit in 1925. The second unit of the building, connecting the first unit with the Service and Stores Build-

FIG. 3. SPACE IS PROVIDED IN THE TURBINE ROOM FOR ANOTHER TURBINE

This is a view in the turbine room of the Purdue Power Plant. It is an exceptionally neat and attractive place, well lighted, and finished in two tone cream colored glazed tile. A ten ton hand operated crane is provided for handling equipment. As may be noted separate motor driven exciter sets are provided.

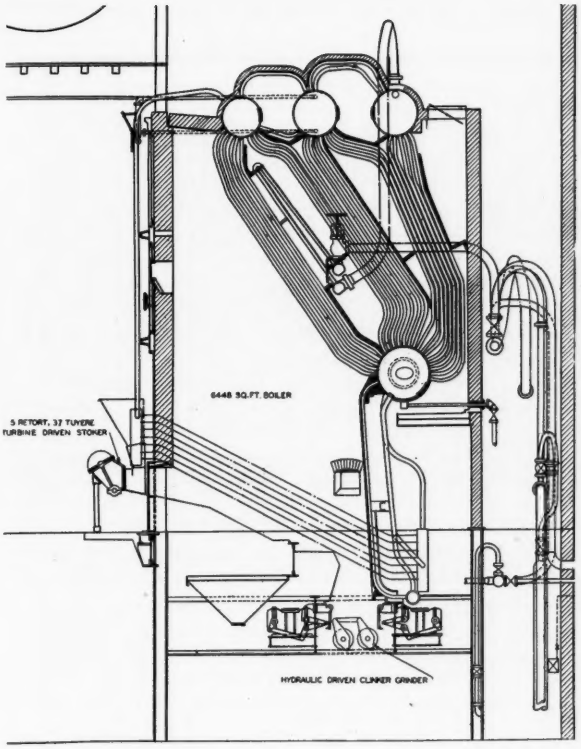


FIG. 4. CROSS SECTION OF THE BOILER SHOWING THE TYPE OF SETTING

ing, was constructed in 1931, and the equipment to complete the layout will be added as necessary. The superstructure is of modern setback style of architecture similar to many of the modern commercial central station plants. It has brick curtain walls with limestone trim and factory type steel windows. The frame is of structural steel with the columns enclosed in the brick work.

Heating System

At the time the heating and power plant was built plans had already been formulated for the construction of tunnels for both the replacement of the present conduit type of steam distribution and the caring for future building development, correlated into one system, divided into units which were to be constructed according to the most pressing needs. The general scheme decided upon was a trunk system with separate feeders to the individual buildings. The campus is underlaid with gravel at an average depth of 4 ft. which eliminates the necessity of installing a special drainage system to handle seepage water or condensate lost due to a repair. For this purpose a regular 8-in. sewer pipe, the hub of which is fitted with a floor plate, is set in the tunnel floor at 50 ft. intervals.

Ventilation is accomplished through an angular flue cast integral with the tunnel and on one side, over this, is a bench laid up with an open brickwork design and covered with a 3-in. pre-cast slab of concrete. These ventilators are located at approximately 150 ft. intervals and may be closed in winter.

Standard pipe openings, planned of such size to admit 22 ft. of the largest pipe used, are placed in the top conveniently to roadways, or where else necessary. The pipe covering in the tunnel is all moulded 85 per cent magnesia with an 8 ounce canvas jacket sized and painted. The insulation on low pressure and return lines is all standard weight; on high pressure lines is double standard.

From 1926 to 1930 inclusive there was a little in excess of 6400 ft. of tunnel constructed at an average cost for general construction of $16.52 per foot. There was a total of 410,000 lb. of pipe installed ranging in size from 1¼ in. to 16 in. or an average of 64 lb. per foot of tunnel. The piping has all been installed by contract including installation of valves and expansion joints furnished by the owner, at an average cost of 14.98c per pound of pipe.

In addition to the steam distribution system the tunnels also carry the electric lines, water lines and air lines for the buildings having pneumatic temperature control. The electric lines are all lead sheath cables and are laid in slots on the side of the tunnel opposite the steam lines.

The system, designed for the utilization of exhaust steam from the turbo-generators and auxiliaries in the power plant for the heating of buildings, includes also high pressure steam distribution which serves two purposes, that of supplying steam for process work in the various laboratories and that of boosting the pressure in remote parts of the low pressure lines when the heating load is heavy. This last mentioned fact made it pos-

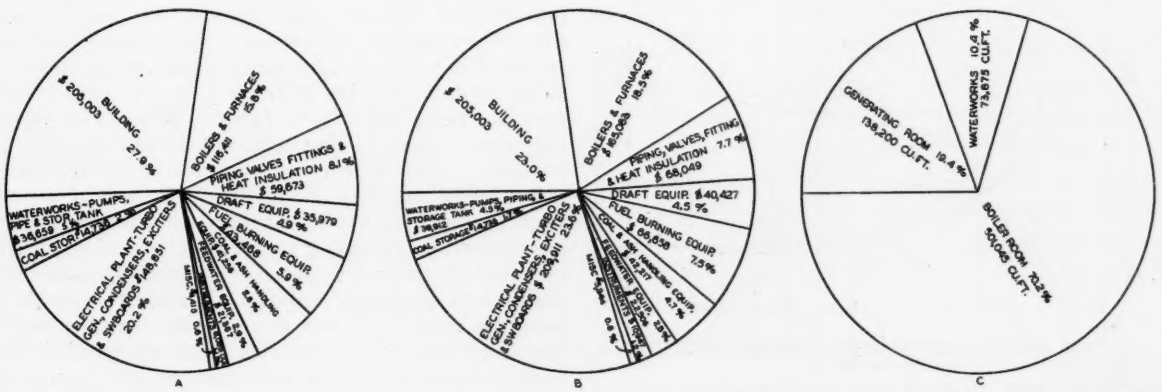

BUILDING $ 205,003 27.0 %
BOILERS & FURNACES $ 118,481 15.6 %
PIPING, VALVES, FITTINGS & HEAT INSULATION $ 59,673 8.1 %
DRAFT EQUIP. $ 35,979 4.9 %
FUEL BURNING EQUIP. 5.0 %
ELECTRICAL PLANT-TURBO GEN., CONDENSERS, EXCITERS & SWBOARDS $ 148,851 20.2 %
WATERWORKS-PUMPS, PIPE & STOR. TANK $ 38,658 5.3 %
A
BUILDING $ 205,003 23.0 %
BOILERS & FURNACES $ 83,063 18.5 %
PIPING, VALVES, FITTING & HEAT INSULATION $ 68,049 7.7 %
DRAFT EQUIP. $ 40,427 4.5 %
FUEL BURNING EQUIP. 7.5 %
ELECTRICAL PLANT-TURBO GEN., CONDENSERS, EXCITERS & SW BOARDS $ 204,911 23.0 %
WATERWORKS-PUMPS, PIPING & STORAGE TANK $ 39,912 4.5 %
B
GENERATING ROOM 138,200 CU.FT. 19.4 %
WATERWORKS 10.4 % 73,875 CU.FT.
BOILER ROOM 70.2 % 500,045 CU.FT.
C

FIG. 5. COST DIAGRAMS, A, SHOWING THE COST OF THE PLANT AT PRESENT; B, SHOWING THE ESTIMATED TOTAL COST COMPLETED WITH TWO MORE BOILERS AND ANOTHER TURBINE, AND C, A DIAGRAM SHOWING THE DISTRIBUTION OF BUILDING VOLUME

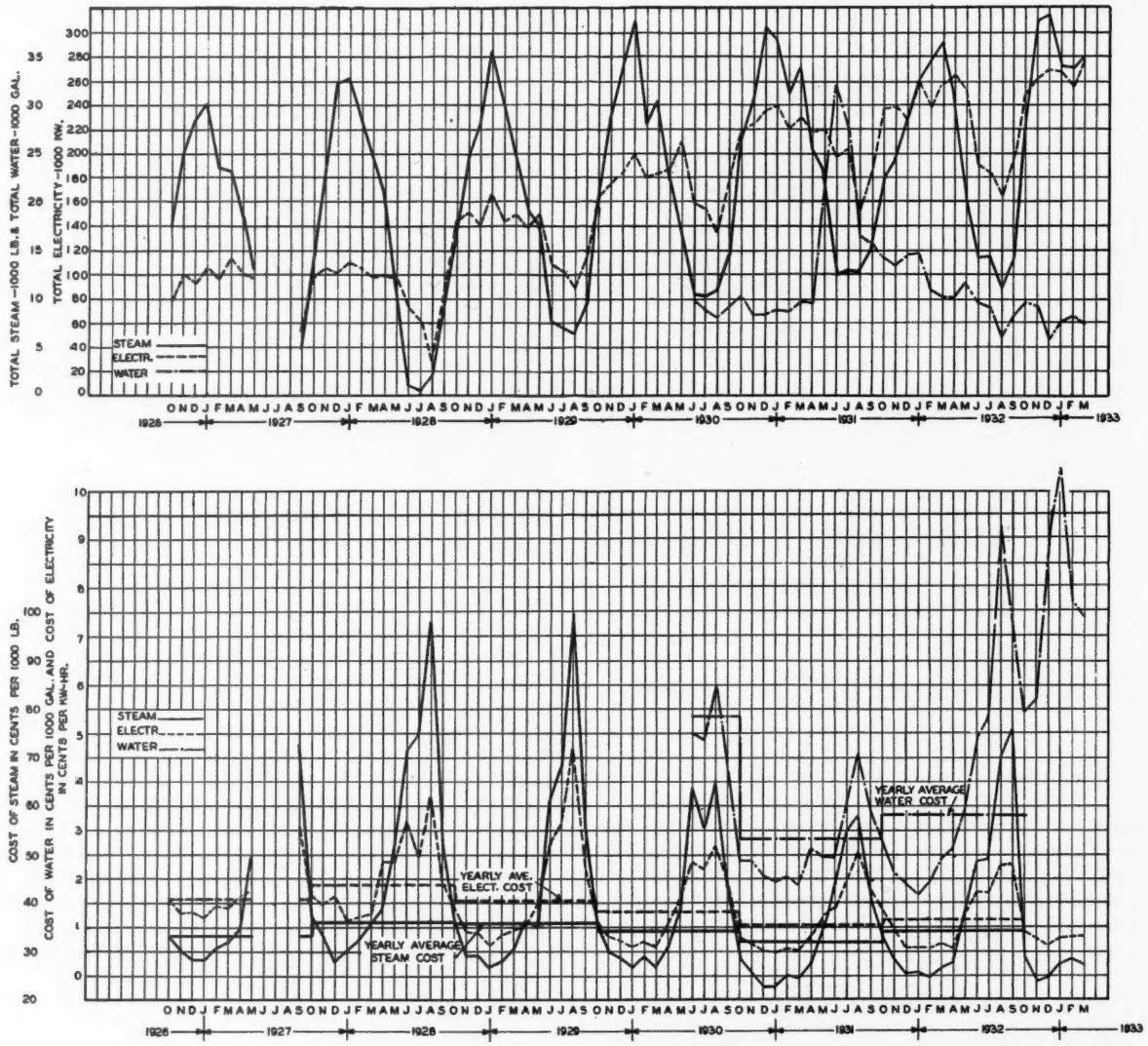

TOTAL STEAM—1000 LB.& TOTAL WATER—1000 GAL.
TOTAL ELECTRICITY—1000 KW.
STEAM
ELECTR.
WATER
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M
1926
1927
1928
1929
1930
1931
1932
1933
COST OF STEAM IN CENTS PER 1000 LB.
COST OF WATER IN CENTS PER 1000 GAL. AND COST OF ELECTRICITY IN CENTS PER KW-HR.
STEAM
ELECTR.
WATER
YEARLY AVE. ELECT. COST
YEARLY AVERAGE STEAM COST
YEARLY AVERAGE WATER COST

FIG. 6. UNIT COST CURVES OF STEAM, ELECTRICITY AND WATER FOR A PERIOD OF 7 YEARS

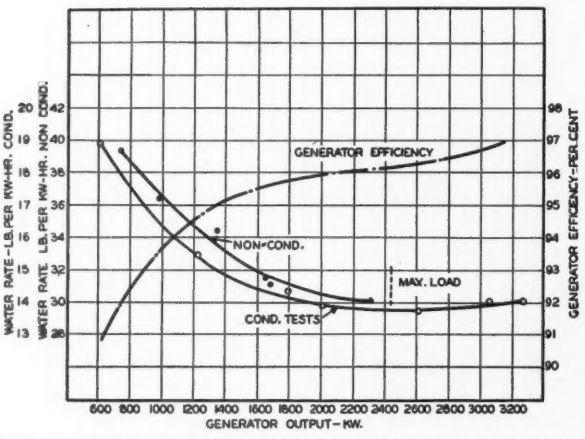

WATER RATE—LB. PER KW-HR. COND.
WATER RATE LB. PER KW-HR. NON COND.
GENERATOR EFFICIENCY—PER CENT
GENERATOR EFFICIENCY
NON-COND.
MAX. LOAD
COND. TESTS
600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200
GENERATOR OUTPUT—KW.

FIG. 7. CURVES SHOWING THE PERFORMANCE OF THE TURBINE UNDER TEST

sible to keep the low pressure pipe sizes smaller, with the attendant savings, than would have otherwise been possible and through small auxiliary connections improve the reliability of service. The booster lines are arranged in banks of three each having a small reducing valve between the high and low pressure sides. Each reducing valve is set for a different pressure in ranges one pound apart. Using small valves and a range of pressure gives better operation, greater safety, easier maintenance and they are cheaper. In case of a very small heating load when the turbines in the power plant are operating condensing the heating load may be carried entirely through the booster stations. In most cases the natural contour of the grounds made it possible to have the condensate flow in the same direction as the flow of the steam to the boosting stations where it is discharged through traps to condensate return pumps; 85 to 90 per cent of the condensate is returned to the plant.

List of Principal Equipment Purdue University Power Plant

BOILERS

Boilers—Babcock & Wilcox Co., two 3-pass, 6448 sq. ft., 210 lb. gage, Stirling boilers, each with 960 sq. ft. of convection superheater surface designed to give 150 deg. superheat. Normal capacity 28,160 lb. per hr., maximum capacity 44,740 lb. per hr. Furnace volume 2690 cu. ft. with 185 sq. ft. of American Engineering Co. water walls made up of cast-iron blocks.

Stokers—American Engineering Co., two, 5 retort, 37 tuyere Taylor stokers, projected grate area of 144.2 sq. ft., designed to burn 43.4 lb. of coal per sq. ft. per hr. Driven by Terry turbines. Complete with hydraulic driven clinker grinders.

Forced Draft Fan—American Blower Co., one, 64,000 c.f.m., 7 in. water gage, forward curve blade, forced draft fan driven by a 110 hp., 1105 r.p.m., single stage 190 lb. General Electric noncondensing turbine.

Boiler Feed Pump—Worthington Pump & Mach. Corp., one, 400 g.p.m., 570 ft. head, 2 stage centrifugal pump driven by a Westinghouse 3000 r.p.m., 95 hp., 190 lb. pressure non-condensing steam turbine.

Feedwater Heater—Cochrane Corp., one V-notch metering deaerating heater, capacity 250,000 lb. per hr., from 135 to 210 deg. F.

Ash Conveyor .....Jeffrey Mfg. Co.

Boiler Feed Regulators.....Swartwout Co.

Combustion Control .....Carrick Engineering Co.

Soot Blowers .....Diamond Power Specialty Corp.

Safety Valves .....Crane Co.

Steam Traps .....Swartwout Co.

Superheater Safety Valves .....Lunkenheimer Co.

Water Columns .....Reliance Gauge Column Co.

Weigh Larry .....Freeman-Riff Co.

TURBINE

Turbo-Generator—Westinghouse Elec. & Mfg. Co., 2500-kw., 3600-r.p.m., 190-lb. gage, 150 deg. superheat, condensing bleeder turbine driving a 3125-kv.a., 0.8-p.f., 2300-v., 3-ph., 60-cycle generator at 3600-r.p.m.

Condenser—Foster Wheeler Corp., one, 2530 sq. ft., 2-pass surface condenser with ⅝-in. O.D. No. 18-B.w.g. Muntz metal tubes. Capacity 38,500 lb. of steam per hr. at 3 in. of mercury, with 4350 g.p.m. of 85 deg. F. cooling water.

Circulating Pump—One, Foster Wheeler Corp., size 12, 4350-g.p.m., 50.5-ft. head single stage centrifugal pump driven by a General Electric 75-hp., 1160-r.p.m., 2300-v. induction motor.

Hot Well Pump—Foster Wheeler Corp., one, 2½ by 4-in., 115-g.p.m., 56-ft. head centrifugal pump, driven by a 5-hp., 1150-r.p.m., 440-v. induction motor.

Vacuum Pump—Foster Wheeler Corp., one, twin, 2-stage steam jet with inter and after cooler. Capacity each stage 10 c.f.m. of free air at 3 in. absolute and operating at 175 lb. steam pressure. 100 deg. superheat.

Air Leakage Meter...Foster Wheeler Corp.

Exciter—Fort Wayne Electric Works, one, 50-kw., 125-v., d.c. shunt wound generator. Driven by a 75-hp., 2300-v., 1200-r.p.m. motor.

Atmospheric Relief Valves..Cochrane Corp.

Generator Air Cooler .....Griscom Russell Co.

Tachometer.....James G. Biddle Co.

Turbine Oil Cooler .....Andale Co.

Turbine Oil Pump .....Worthington Pump and Mach. Corp.

VALVES AND PIPING

Check Valves .....Lunkenheimer Co.

Elbows & Fittings.....Stockham Pipe & Fittings Co.

Expansion Joints, Copper.....Crane Co.

Expansion Joints, Rubber.U. S. Rubber Co.

Piping.....Spang-Chalfant & Co.

Reducing Valves .....Boylston Steam Specialty Co.
Fisher Governor Co.
Foster Engineering Co.

Valves.....Crane Co.
Lunkenheimer Co.
Wm. Powell Co.

INSTRUMENTS

Boiler Panel—Hays Corp., complete with Hays 5 pointer draft gage, CO_2 and draft recording gages, and Cochrane flow meters.

Turbine Panel.....Cochrane Corp.

Flow Meters.....Bailey Meter Co.
Cochrane Corp.

Draft Gage.....Ellison Draft Gage Co.

Mercury Columns .....Consolidated Ashcroft Hancock Co.

Pressure Gages .....Consolidated Ashcroft Hancock Co.
.....Crosby Steam Gauge and Valve Co.
.....Foxboro Co.
.....McDonough Automatic Regulator Co.

Water Meter .....Worthington Pump & Mach. Corp.

MISCELLANEOUS

Deep Well Pump—Worthington Pump & Mach. Corp., three, No. 12, 750-g.p.m., 213-ft. head Coniflo deep well pumps driven at 1750 r.p.m. by General Electric 75-hp., 2200-v. vertical induction motors.

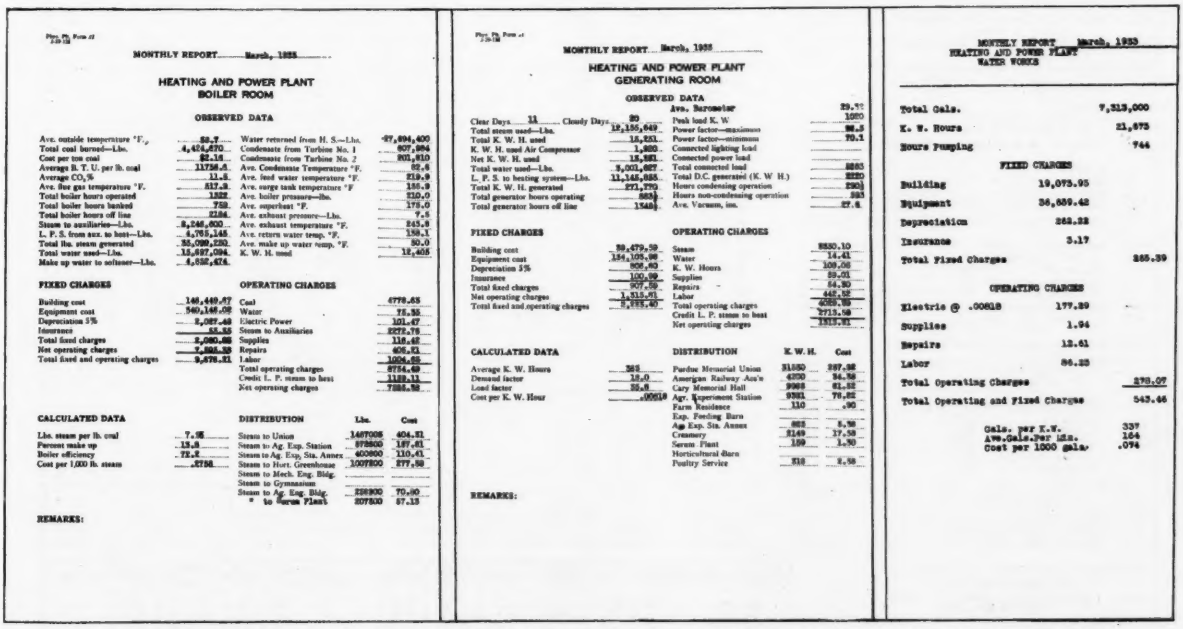
Booster Pumps—Worthington Pump & Mach. Corp., four, 750-g.p.m., 80-ft. head, single stage, 1750-r.p.m., centrifugal pumps. Three driven by General Electric 25-hp., 440-v. induction motors and one driven by a D. E. Whiton Machine Co. 20-hp., 190-lb. steam pressure non-condensing turbine.

Fire Pump—Dean Hill Pump Co., one, 10-in., 1750-g.p.m., 162-ft. head centrifugal single stage fire pump driven at 2300-r.p.m. by a D. E. Whiton Machine Co. 112 to 160-hp., 105 to 190-lb. steam pressure non-condensing turbine.

Stairways & Grating.....Hoosier Steel & Wire Co.

Thermometers .....Foxboro Co.

NOTE: For list of equipment in initial installation in 1925 see p. 408.



MONTHLY REPORT March, 1933

HEATING AND POWER PLANT
BOILER ROOM

OBSERVED DATA

Ave. outside temperature °F.	32.7	Water returned from H. S.—Lbs.	47,494,400
Total coal burned—Lbs.	4,424,670	Condensate from Turbine No. 1	827,984
Cost per ton coal	$2.15	Condensate from Turbine No. 2	801,610
Average B. T. U. per lb. coal	11736.5	Ave. Condensate Temperature °F.	92.6
Average CO_2%	11.5	Ave. feed water temperature °F.	219.9
Ave. flue gas temperature °F.	517.3	Ave. surge tank temperature °F	185.9
Total boiler hours operated	1322	Ave. boiler pressure—lbs.	210.0
Total boiler hours banked	752	Ave. superheat °F.	178.0
Total boiler hours off line	2184	Ave. exhaust pressure—Lbs.	7.6
Steam to auxiliaries—Lbs.	2,246,600	Ave. exhaust temperature °F.	245.8
L. P. S. from aux. to heat—Lbs.	1,765,145	Ave. return water temp. °F.	158.1
Total lbs. steam generated	35,090,250	Ave. make up water temp. °F.	50.0
Total water used—Lbs.	15,687,094	K. W. H. used	12,405
Make up water to softener—Lbs.	4,652,474		

FIXED CHARGES		OPERATING CHARGES	
Building cost	146,440.67	Coal	6778.45
Equipment cost	540,146.09	Water	75.35
Depreciation 3%	2,087.48	Electric Power	101.47
Insurance	53.55	Steam to Auxiliaries	2272.75
Total fixed charges	2,080.48	Supplies	118.62
Net operating charges	7,591.33	Repairs	406.21
Total fixed and operating charges	9,670.81	Labor	1004.65
		Total operating charges	9754.49
		Credit L. P. steam to heat	1119.11
		Net operating charges	7385.82

CALCULATED DATA		DISTRIBUTION	Lbs.	Cost
Lbs. steam per lb. coal	7.95	Steam to Union	1467008	404.21
Percent make up	13.8	Steam to Ag. Exp. Station	672800	187.81
Boiler efficiency	72.2	Steam to Ag. Exp. Sta. Annex	400900	110.41
Cost per 1,000 lb. steam	.2756	Steam to Hort. Greenhouse	1007800	277.58
		Steam to Mech. Eng. Bldg.		
		Steam to Gymnasium		
		Steam to Ag. Eng. Bldg. * to Power Plant	238900 207800	70.80 57.15

REMARKS:

MONTHLY REPORT March, 1933

HEATING AND POWER PLANT
GENERATING ROOM

OBSERVED DATA

Clear Days 11 Cloudy Days	20	Ave. Barometer	29.77
Total steam used—Lbs.	12,155,649	Peak load K. W.	1265
Total K. W. H. used	18,251	Power factor—maximum	98.5
K. W. H. used Air Compressor	1,220	Power factor—minimum	70.1
Net K. W. H. used	15,521	Connected lighting load	
Total water used—Lbs.	5,001,627	Connected power load	
L. P. S. to heating system—Lbs.	11,145,255	Total connected load	1265
Total K. W. H. generated	271,770	Total D.C. generated (K. W. H.)	2220
Total generator hours operating	383½	Hours condensing operation	2301
Total generator hours off line	1548½	Hours non-condensing operation	383
		Ave. Vacuum, ins.	27.6

FIXED CHARGES		OPERATING CHARGES	
Building cost	39,479.59	Steam	8550.10
Equipment cost	154,105.98	Water	14.41
Depreciation 3%	508.80	K. W. Hours	109.06
Insurance	100.09	Supplies	59.01
Total fixed charges	607.89	Repairs	54.30
Net operating charges	1,515.91	Labor	445.52
Total fixed and operating charges	2,223.40	Total operating charges	9230.39
		Credit L. P. steam to heat	2713.56
		Net operating charges	1515.91

CALCULATED DATA		DISTRIBUTION	K. W. H.	Cost
Average K. W. Hours	362	Purdue Memorial Union	31350	287.92
Demand factor	18.0	Amerigan Railway Ass'n	4200	34.58
Load factor	33.8	Cary Memorial Hall	9968	81.92
Cost per K. W. Hour	.00818	Agr. Experiment Station	9201	79.62
		Farm Residence	110	.90
		Exp. Feeding Barn		
		Ag. Exp. Sta. Annex	863	5.70
		Creamery	2149	17.59
		Serum Plant	159	1.30
		Horticultural Barn		
		Poultry Service	516	2.59

REMARKS:

MONTHLY REPORT March, 1933
HEATING AND POWER PLANT
WATER WORKS

Total Gals.		7,313,000
K. W. Hours		21,975
Hours Pumping		744
FIXED CHARGES		
Building	19,073.95	
Equipment	36,859.42	
Depreciation	262.22	
Insurance	3.17	
Total Fixed Charges		365.39
OPERATING CHARGES		
Electric @ .00818	177.29	
Supplies	1.94	
Repairs	12.61	
Labor	86.23	
Total Operating Charges		278.07
Total Operating and Fixed Charges		643.46
Gals. per K.W.		337
Avg.Gals.Per Lb.		164
Cost per 1000 gals.		.074

FIG. 8. DETAILS OF COSTS FOR THE MONTH OF MARCH, 1933, FOR STEAM, ELECTRICITY AND WATER

POWER PLANT ENGINEERING September 1933

Operation of Horizontal Underfeed Stokers

Study of a Particular Stoker from Acceptance Test Through to Final Operating Conditions Shows Effects of Adjustments and Variations in Efficiency. By J. F. Barkley[1] and L. R. Burdick[2].

OPERATING OBSERVATIONS covering a full series of conditions were made on a horizontal 6-retort underfeed stoker installed under a longitudinal-drum water-tube boiler of 5110 sq. ft. heating surface.

[1]Supervising Engineer and [2]Associate Engineer, Fuel Economy Service, U. S. Bureau of Mines. Published by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.

Figure 1 shows the general layout. The coal used was low-volatile, low-ash, eastern semi-bituminous coal having relatively high ash fusion and heavy caking characteristics. Referring to Table I, Test No. 1 was a 10-hr. acceptance test, showing an over-all efficiency of 83.2 per cent when developing 533 b.hp. The heat

TABLE I. TEST DATA AND RESULTS COVERING A COMPLETE PERIOD FROM ACCEPTANCE TO FINAL OPERATING CONDITIONS

Item No.										
1.	Test		#1	#2	#3	#4	Average #3 & 4	#5	#6	Average #5 & 6
2.	Duration	hrs.	9.97	2.05	6.33	7.00		6.33	6.33	
3.	Boiler No.		3	3	3	3		3	3	
4.	Type of boiler		Longitudinal Drum Water Tube							
5.	Type of stoker		Horizontal Rear Dump Underfeed							
6.	Grate surface	sq.ft.	86.6							
7.	Type of fuel		Semibituminous coal							
8.	Boiler heating surface	sq.ft.	5110							
9.	Ratio of heating surface to grate surface		59.0							
10.	Combustion space volume (approximate)	cu.ft.	710							
	Average Pressures and Temperatures:									
11.	Steam pressure by gage	lbs./sq.in.	71.7	66.4	67.4	66.8		67.7	71.1	
12.	Force of draft - combustion chamber	"H_2O	-0.028	-0.145	-0.05	-0.05		-0.05	-0.05	
	- boiler breaching ahead of damper	"H_2O	-0.078	-0.498						
13.	Pressure of air at stoker	"H_2O	1.50	3.73	1.45	1.42	1.44	1.27	1.67	1.47
14.	Temperature of feed water entering boiler	°F.	79.7	79.5	204.4	204.1		204.3	208.6	
15.	" " calorimeter	°F.	262.2	265.2						
16.	" " escaping gases leaving boiler	°F.	371	454	388	385		391	402	
17.	" " boiler room	°F.	89.7	81.8	77.4	77.4		78.1	78.4	
	Quality of Steam:									
18.	Percentage of moisture in steam	%	1.082	0.789						
19.	Factor of correction for quality of steam		.99146							
	Total Quantities:									
20.	Total weight of coal as fired	lbs.	15,336							
21.	Percentage of moisture in coal as fired	%	2.8							
22.	Total weight of dry coal	lbs.	14,907							
23.	Total weight of dry ash and refuse into ash pit	lbs.	994							
24.	Percentage of ash and refuse based on dry coal	%	6.7							
25.	Total weight of feed water	lbs.	158,013							
26.	Total water evaporated corrected for steam quality	lbs.	156,684							
27.	Factor of evaporation		1.17065							
28.	Total equivalent evaporation from and at 212°	lbs.	183,399							
	Hourly Quantities and Rates:									
29.	Dry coal per hour	lbs.	1,495							
30.	Dry coal per sq.ft. of grate surface per hour	lbs.	17.3	34*	19.0	19.5	19.3	16.5	17.9	17.2
31.	Water evaporated per hour corrected for quality of steam	lbs.	15,714							
32.	Equivalent evaporation from and at 212° per hour	lbs.	18,395							
33.	Equivalent evaporation from and at 212° per hour per sq.ft. of boiler heating surface	lbs.	3.60							
	Capacity:									
34.	Rated boiler horsepower	hp.	511							
35.	Boiler horsepower developed	hp.	533.2	1021*	574	578	576	515	556	536
36.	Percentage of rated capacity developed	%	104.3	200*	112	113	113	101	109	105
	Economy:									
37.	Water fed per lb. of coal as fired	lbs.	10.30							
38.	Water evaporated per lb. of dry coal	lbs.	10.51							
39.	Units of evaporation per lb. of coal as fired	lbs.	11.96							
40.	Units of evaporation per lb. of dry coal	lbs.	12.30							
41.	Analysis of Dry Gases by Volume:									
	a. Carbon dioxide (CO_2)	%	13.77	14.90	11.74	12.66	12.20	12.32	11.76	12.04
	b. Oxygen (O_2)	%	5.05	4.13	7.16	6.08	6.62	6.58	7.11	6.85
	c. Carbon monoxide (CO)	%	0.22	0.83	0.15	0.27	0.21	0.11	0.08	0.10
	d. Nitrogen (N_2) by difference	%	80.96	80.74	80.95	80.99		80.99	81.05	
42.	Lbs. of dry flue gases per lb. of carbon	lbs.	18.11	16.83	21.14	19.51		20.27	21.23	
43.	" " " " " " " " dry coal	lbs.	14.56	13.24	17.06	15.37		16.84	17.68	
44.	Proximate Analysis of Coal as Fired:									
	a. Moisture	%	2.8				3.4			
	b. Volatile matter	%	21.7				16.9			
	c. Fixed carbon	%	68.8				73.0			
	d. Ash	%	6.7				6.7			
45.	Ultimate Analysis of Dry Coal:									
	a. Carbon (C)	%	81.6				84.5			
	b. Hydrogen (H_2)	%	4.7				4.3			
	c. Oxygen (O_2)	%	4.3				2.5			
	d. Nitrogen (N_2)	%	1.6				1.2			
	e. Sulphur (S)	%	0.9				0.6			
	f. Ash	%	6.9				6.9			
46	B. t. u. per lb. of dry coal	B.t.u.	14,350				14,680			
47.	Analysis of Dry Ash and Refuse:									
	a. Combustible	%	14.6	30.0*	35.7	45.1	40.4	17.3	15.1	16.2
	b. Ash	%	85.4	70.0*	64.3	54.9		82.7	84.9	
48.	Heat Balance, Based on Dry Coal:		B.t.u. / %	B.t.u. / %	B.t.u. / %	B.t.u. / %		B.t.u. / %	B.t.u. / %	
	a. Heat absorbed by boiler		11,936 / 83.2	11,563 / 80.6**	11,658 / 79.4**	11,462 / 78.1**	78.8**	12,040 / 82.0**	11,980 / 81.6**	81.8**
	b. Loss due to heat carried away by steam in flue gases		528 / 3.7	549 / 3.8	501 / 3.4	501 / 3.4		502 / 3.4	504 / 3.4	
	c. Loss due to heat carried away by dry flue gases		983 / 6.8	1,183 / 8.3	1,272 / 8.7	1,135 / 7.7		1,265 / 8.6	1,373 / 9.4	
	d. Loss due to carbon monoxide		128 / 0.9	121 / 0.8	103 / 0.7	167 / 1.1		75 / 0.5	57 / 0.4	
	e. Loss due to combustible in ash and refuse		172 / 1.2	432 / 3.0	599 / 3.8	828 / 5.7		211 / 1.5	179 / 1.2	
	f. Loss due to unconsumed hydrogen, hydrocarbons, to radiation and unaccounted for		603 / 4.2	502 / 3.5**	587 / 4.0**	587 / 4.0**		587 / 4.0**	587 / 4.0**	
	g. Total (see Item 46)		14,350 / 100.0	14,350 / 100.0	14,680 / 100.0	14,680 / 100.0		14,680 / 100.0	14,680 / 100.0	

NOTE- * approximate
** radiation and unaccounted for estimated, and efficiency estimated from heat balance

TABLE II. TABULATION OF STOKER ADJUSTMENTS AND RAM TRAVELS

Main Ram Block Position	Secondary Ram Pin Position	Main Ram Travel, Approx. Inches	Secondary Ram Travel, Approx. Inches	Ratio Main Ram to Sec. Ram Travel
1	1	12	5.5	2.18
1	2	12	7.0	1.71
1	3	12	8.5	1.41
1	4	12	10.0	1.20
2	1	10	3.5	2.86
2	2	10	5.0	2.00
2	3	10	6.5	1.54
2	4	10	8.0	1.25
3	1	8	1.5	5.33
3	2	8	3.0	2.67
3	3	8	4.5	1.78
3	4	8	6.0	1.33
4	1	6	None	....
4	2	6	1.0	6.00
4	3	6	2.5	2.40
4	4	6	4.0	1.50
5	1	4	None	....
5	2	4	None	....
5	3	4	0.5	8.00
5	4	4	2.0	2.00

balance for this test gave a reasonable loss "to radiation and unaccounted for," thus indicating that the actual efficiency obtained was about as shown. Test No. 2 was a 2-hr. capacity test, showing an estimated efficiency of 80.6 per cent when developing about 1021 b.hp. During these tests, the stoker was operated at constant load by an expert fireman in the employ of the stoker manufacturer.

After the equipment had been in operation for some months, further tests showed an average operating efficiency of about 78.8 per cent. Tests No. 3 and No. 4 are representative. During these tests, the stoker was operated by the regular plant fireman. Studies were next made to determine the effects of stoker adjustments and to arrive at the best operating conditions for the regular plant heating load. Table II shows the possible adjustments on the stoker and their effect on ram travel and on fuel movement or fuel bed shape. The main or coal-feeding ram travel governs the amount of coal put into the furnace at the front wall; the secondary ram travel governs the amount of coal taken away from the front wall and pushed further along into the furnace, therefore the ratios tabulated in the last column give an indication of the general contour of the fuel bed on the front half of the stoker: the higher the ratio, the thicker the bed at the front wall in relation to that near the middle of the stoker.

Table III shows representative observations for different stoker adjustments. The effect, as shown in the table, upon the over-all efficiency of the various stoker adjustments was quite small. This was due in part to careful stoker operation. Greater differences in efficiency due to these adjustments would occur with less careful attention. The final adjustment chosen gave the highest efficiency obtained and also required the least operating attention, thus tending to offset careless operation. Some difficulty with any of the adjustments was experienced with the formation of clinkers on the side walls toward the front of the stoker. Such clinkers would retard the movement of the fuel in the outside retorts.

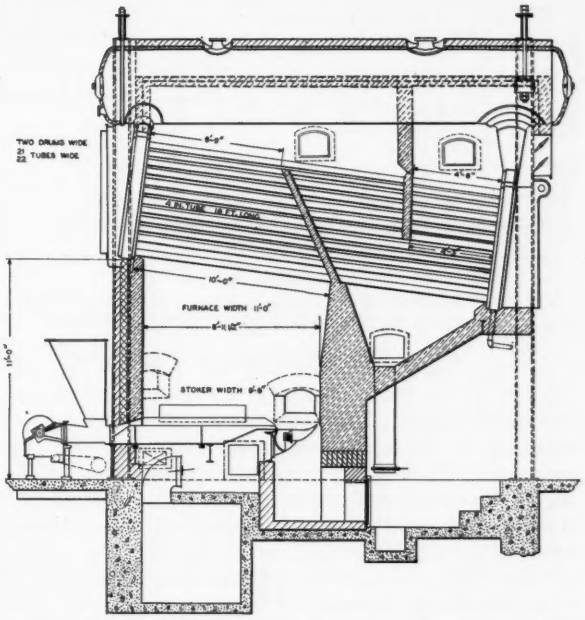


FIG. 1. GENERAL LAYOUT OF THE BOILER AND STOKER

A large amount of carbon monoxide is likely to be produced with this stoker when poorly operated. Figure 2 shows the carbon monoxide produced for various carbon dioxide contents. This curve is representative of good plant operation when the stoker is properly adjusted. Figure 3 shows the over-all efficiencies at about 110 per cent rating for various carbon dioxide contents in the flue gases.

TABLE III. OBSERVATIONS MADE FOR VARIOUS STOKER ADJUSTMENTS

Duration hrs.	Stoker Adjustment: Position Number: Main Ram	Sec. Ram	Main Ram Travel	Sec. Ram Travel	Ratio Main Ram Travel to Sec. Ram Tr.	Average B.h.p. Load Carried	Windbox Pressure Inches water	Furnace Draft Inches water	Per Cent CO_2	Per Cent CO	Fuel Bed Depth 18" from Front wall	Fuel Bed Depth 24" from Bridge wall	Distance from Bridge wall	Relative Value of Adjustment Based on Efficiency Only (Careful Stoker Operation)	Remarks
7.0	2	2	10"	5.0"	2.00	575	1.45"	0.05"	11.7	.15	17"	16"	3"		Adjustment as found.
"	"	"	"	"	"	580	1.42	"	12.7	.27	17	17	4		Operator apt to produce too much CO.
Avg.	"	"	"	"	"	578	1.44	"	12.2	.21	17	16.5	3.5	996	A fair adjustment.
7.0	3	2	8"	3.0"	2.67	545	1.42	"	12.8	.32	18	17	9		Too much CO. Deficiency
"	"	"	"	"	"	555	1.58	"	12.6	.42	20	17	10		of air at front wall.
Avg.	"	"	"	"	"	550	1.50	"	12.7	.37	19	17	9.5	996	Fuel bed tends to mat. (cake over the top).
6.0	1	1	12"	5.5"	2.18	—	1.37	"	12.3	.21	19	16	2	999	Fuel bed tends to mat. CO rather high.
7.0	1	2	12"	7.0"	1.71	580	1.27	0.07"	13.0	.25	18	16	2		Too much CO, due chiefly to too active
"	"	"	"	"	"	570	1.34	0.05"	12.6	.31	20	17	2		a fuel bed at rear. Sec. ram travel so
"	"	"	"	"	"	575	1.38	"	13.3	.34	17	17	0_2"		long that excessive attention is required
"	"	"	"	"	"	610	1.51	"	13.8	.21	17	16	0"		to prevent trouble at rear from CO and
"	"	"	"	"	"	620	1.57	"	12.2	.20	17	16	1		clinker.
"	"	"	"	"	"	610	1.59	"	12.5	.25	18	16	2		Fuel bed tends to mat.
Avg.	"	"	"	"	"	583	1.48	0.05"	12.7	.29	18	16.5	1	1000	
7.0	2	3	10"	6.5"	1.54	535	—	"	12.7	.42	17	17	0_2"	994	Too much CO at rear of fuel bed.
7.0	1	3	12"	8.5"	1.41	570	1.46	"	11.0	.14	16	16	4	982	An excess of air at front wall, causing the low CO_2, and too active a fuel bed at rear, causing CO.
7.0	3	3	8"	4.5"	1.78	535	1.29	0.06"	11.9	±10	19	17	5		
"	"	"	"	"	"	535	1.19	0.05"	13.7	.55	20	17	8		Final setting: best adjustment for
"	"	"	"	"	"	550	1.30	"	12.4	.17	16	15	5		plant conditions.
"	"	"	"	"	"	525	1.50	"	11.7	.09	15	13	6		
"	"	"	"	"	"	595	1.60	"	12.3	.08	17	15	3		This setting required the least operating
"	"	"	"	"	"	515	1.27	"	12.5	.11	17	14	5		attention.
"	"	"	"	"	"	535	1.67	"	11.8	.08	17	15	6		
Avg.	"	"	"	"	"	544	1.43	0.05"	12.3	.17	17.5	15	3.5	1000	NOTE — * Depth about 2" at Bridgewall. ** " " 1" " "

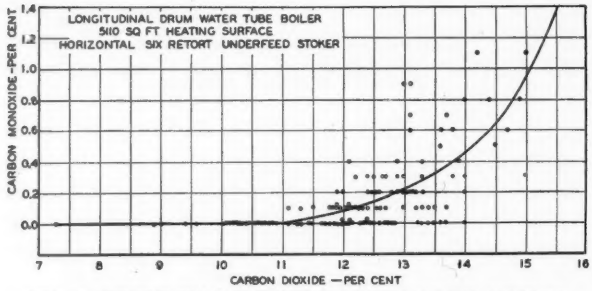

LONGITUDINAL DRUM WATER TUBE BOILER
5110 SQ FT HEATING SURFACE
HORIZONTAL SIX RETORT UNDERFEED STOKER
CARBON MONOXIDE - PER CENT
CARBON DIOXIDE — PER CENT

FIG. 2. THERE WAS A TENDENCY FOR CO TO APPEAR WHEN THE CO_2 EXCEEDED 11.5 PER CENT

It was found that good burning down of the combustible in the refuse was largely a problem of operating manipulation during the time just preceding the cleaning of the fire, being rather independent of the stoker adjustments. The last point for emission of air under pressure was at the rear tuyères, a nonperforated dump-plate reaching from this point a distance of about 24 in. to the bridgewall. Air for combustion passing through any accumulation on the dump-plate must come from the ashpit by natural draft or work its way from the rear tuyères. The dump-plate as designed and sized could not readily be adapted to serve as grate area. Ex-

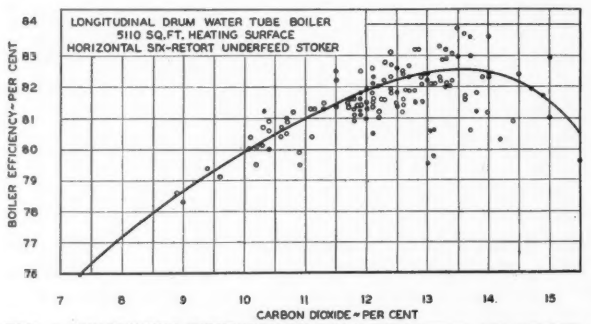

LONGITUDINAL DRUM WATER TUBE BOILER
5110 SQ.FT. HEATING SURFACE
HORIZONTAL SIX-RETORT UNDERFEED STOKER
BOILER EFFICIENCY - PER CENT
CARBON DIOXIDE - PER CENT

FIG. 3. MAXIMUM EFFICIENCY WAS REACHED AT ABOUT 13.5 PER CENT CO_2

periments with perforations in the dump-plate and the emission of air under pressure into the ash pit showed relatively small improvement in fuel-burning. An ideal fuel bed for this stoker would be one that covers the rear tuyères and ends abruptly near the front of the dump-plate. In practical operation it was not possible to maintain the proper amount of fuel over the rear tuyères without spilling considerable fuel onto the dump-plate. Previous to dumping, it was necessary to burn down this fuel. Large pieces of coke were broken with a hook to hasten the burning.

In burning down, the strokes of the rams were shortened, thereby reducing the amount of coal fed to the furnace and retarding the amount of fuel moved to the dump-plates. During this stage the fuel bed on the rear half of the stoker burned down to some extent. After dumping, the amount of stroke was increased to build up the rear half of the fuel bed to its correct shape. For the load conditions at this plant it was found that a time interval of about 8 hr. between cleanings was desirable. Tests No. 5 and No. 6 show the improvement over No. 3 and No. 4 when the regular plant firemen had learned the proper manipulation in burning down the refuse.

Benson Boiler Progress

AS A RESULT of investigation work done on salt deposits in tubes of Benson boilers, Siemens-Schuckertwerke announce that these boilers can now be safely operated below the critical pressure. The chief advantage of this is that excess feed pump work is eliminated.

First trials to operate a Benson boiler at under-critical pressures were made by Professor E. Josse of the Technische Hochschule, Berlin, with the test boiler of his laboratory. Later Siemens-Schuckertwerke operated their large 90,000 lb. per hr. Benson boiler No. 2 at the cableworks Berlin-Gartenfeld below the critical pressure and recently the Benson boiler on the S. S. Uckermark (45,000 lb. per hr.) was worked at 1000 lb., which is a little above the turbine pressure to which the steam had to be throttled. The Langerbrugge Benson boiler 300,000 lb. per hr. is still operating with the critical pressure, because in this plant the high pressure is fully utilized in a turbine.

In the future the Benson boiler with critical pressure will be used in all cases where large units and high load factors call for a maximum efficiency. In all other cases, however, where lower turbine pressures are chosen, the Benson boilers will be operated at accordingly lower pressures. It is obvious that a turbine can be operated with varying live steam pressures but it has been customary in power generation to maintain a constant pressure at the throttle. With the new type of Benson boiler the pressure need not be maintained constant, as it is possible to deliver steam of any pressure at practically constant temperature.

The turbine will operate with the maximum pressure at maximum load and let the pressure adjust itself automatically at partial loads. This is done by the omission of the throttle valve at the turbine inlet and by varying the boiler output in proportion to the turbine load. The turbine construction becomes simpler and the feedpump work reduced. A detailed project has been worked out by Siemens-Schuckertwerke for a peak-load central station with 500 lb. normal and 2000 lb. peak pressure, giving a turbine output ranging from 5000 to 20,000 kw.

Air Compressors for Czechoslovakian Collieries

The Skoda Works Co. of Prague has recently completed a 3500 h.p. steam turbine-driven four-casing turbo-compressor for the Louis pit of the Witkowice collieries at Moravska, Ostrawa. The set runs at 3500 r.p.m. and is capable of delivering 883,000 cu. ft. of air per hour at a pressure of 98 lb. per sq. in. The same company has also lately built for the Betyba pit of the Witkowice concern a four-casing turbo-compressor which at 3600 r.p.m. delivers 706,000 cu. ft. of air per hour at 98 lb. pressure. In the latter case the compressor is driven through gearing by a 2000 kw. alternator generating 3100-volt power at 1480 r.p.m.

IT IS POSSIBLE to store as much as 50,000 ft. lb. of energy in 1 lb. of rubber, whéreas the strongest steel will store only 200 ft. lb. per pound. That is why rubber is one of the most efficient shock absorbers.

REHEAT—— Practice, Operation *and* Control

Cutting Boilers In and Out of Service. Protection of Reheater Elements. Temperature Variation During Starting

DURING STARTING PERIODS, boiler and plant conditions change rapidly necessitating careful attention to details which later on during regular operating conditions take care of themselves. One of the starting problems is the protection of superheater and reheater coils from excessive metal temperatures.

It used to be common practice to flood superheaters during starting up but this has been found to be unnecessary and is now seldom practiced. One of the obvious disadvantages is the deposit of scale from bad water while another is the danger of water hammer if the coils were not thoroughly drained or blown down. Drains provided on the superheater outlet, and opened during the starting period, provide some flow through the tubes to cool the coils somewhat and prevent collection of condensate in the loops.

It is not likely that radiant superheaters in lightly fired furnaces receive a great deal of heat before the boiler is in service. This is obviously true in underfeed stoker fired furnaces where the elements are usually placed in the rear wall and the boiler generally brought up to full pressure before the fire has reached the dump grates below the superheater. Naturally with the grates bare, the furnace is comparatively cool and excessive metal temperatures are not reached.

This is also true of pulverized coal fired furnaces and radiant reheaters and superheaters, as demonstrated very conclusively by tests made at Lakeside. As shown by Fig. 1, if the coal feed during the starting up period does not exceed that corresponding to 50 per cent boiler rating, furnace temperatures do not exceed 1000 deg. F., and metal temperatures range around 900 deg. F. as compared with 900-950 deg. F. under ordinary operating conditions.

Starting Period Lengthened

At this station with the older, heavier forged elements, the coal feed was gradually increased during the 3 hr. starting period until it was quite high when the non-return valves were opened. The new radiant elements of light round tubes have practically no heat storage in the metal to prevent overheating. Furthermore cooling with steam from other boilers or with the boiler's own steam after atmospheric pressure was reached was considered not only inadequate but impractical. Flooding with water was considered but not tried due to stresses involved. Since making the tests shown by Fig. 1, the steady fire method is practiced with a starting period of about 4 hr.

At Edgar where stokers are used, each boiler also has a reheater and the procedure following in bringing the high pressure boilers up to pressure requires 3½ hr. The fire is started at the upper end of the stoker, then all superheater and reheater drains, vents on boiler drum and reheater, 2-in. by-pass between superheater outlet and reheater inlet and the boiler stop valve are opened. The reheater inlet and outlet valves and the non-return valve are closed. As the boiler warms up, sufficient water is fed through the

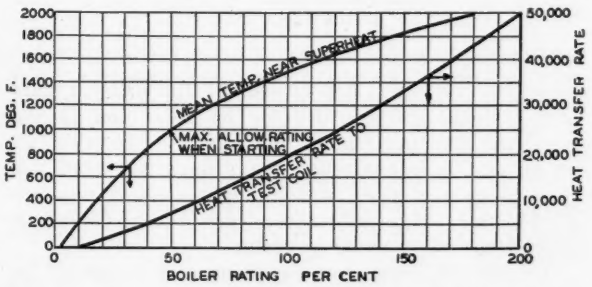

TEMP. DEG. F.
HEAT TRANSFER RATE
BOILER RATING PER CENT
MEAN TEMP. NEAR SUPERHEAT
MAX. ALLOW. RATING WHEN STARTING
HEAT TRANSFER RATE TO TEST COIL

FIG. 1. TEST DATA FROM LAKESIDE SHOW THAT IF THE COAL FEED DURING STARTING DOES NOT EXCEED THAT FOR 50 PER CENT BOILER RATING, FURNACE TEMPERATURES WILL NOT EXCEED 1000 DEG. F.

economizers to prevent steaming. Water is bled through the blow down and from the lower headers of the water wall through a ¼-in. valve on each header to prevent rise of water in the drum.

When the boiler pressure reaches 350 lb., which is the pressure in the low pressure header, the reheater outlet valve is opened after which the superheater and reheater drains are closed. This allows steam to flow through the 2-in. bypass line from the superheater outlet through the reheater to the 350-lb. header. Flow of steam through the bypass connection protects the superheater and reheater while the pressure is coming up on the boiler and saves blowing steam through the superheater and reheater drains.

When the boiler pressure has reached that in the high pressure header the non-return valve opens and allows steam to flow to the header. The reheater inlet valve is then opened and the 2-in. bypass blow down bleeder and the water wall bleeders are closed. While bringing up the boiler the fire must be carefully regulated to prevent unequal expansion strains and excessive superheater and reheater temperatures.

At Gilbert pulverized fuel is used and each boiler

has convection reheat coils above the boiler, somewhat the same as at Edgar. A 2-in. bypass line provided between superheater outlet and gas reheater inlet is installed to allow steam to pass to the reheaters and fill the piping between the reheater and the low pressure turbine inlet. This pipe is closed off at the high pressure turbine exhaust with a hand-operated gate valve and at the low pressure turbine by the intercepting valve. A steam pipe connection to the steam jet air ejectors close to the high pressure exhaust valve is open and makes it possible to heat this line, at the

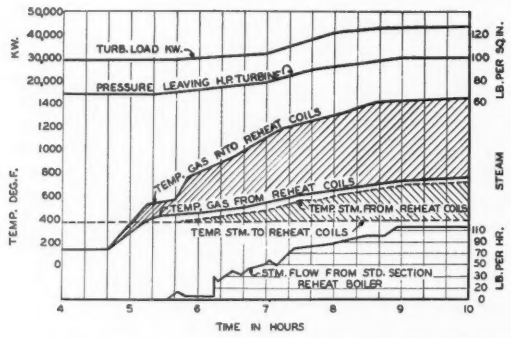


FIG. 2. TEMPERATURE CURVES DURING THE STARTING PERIOD AT COLUMBIA WHERE A SEPARATE REHEAT BOILER IS USED

same time avoiding a dead end at the exhaust gate valve. Vents are provided at the other end of the cross-over pipe in front of the intercepting valve, allowing air to escape when the piping is heated up. These vents are closed with a slight positive pressure in the pipe. The steam condensed in the pipe is drained to the deaerating heater.

One center burner on the front wall is lighted by means of a kerosene flame with one feeder running. The other burners are not cut in until the boiler is brought up to 400 lb. pressure and the turbine is started. Bringing the steam generating unit up from cold condition, the boiler is heated slowly with the one burner in operation and the steam pressure brought up to about 400 lb. pressure in 2½ hr.

Separate Reheat Boilers

In plants having separate reheat boilers, the standard boilers are put in service and the turbine started before the reheat boiler is cut in. During the initial warming up period the reheat coils are bypassed until the boiler is warm. For instance, at Crawford the process of bringing up the reheat unit is practically the same as that of a normal boiler, the single difference being that the steam from the turbine is diverted through the reheater coils at the time when temperature conditions are favorable. The process of letting down is even simpler because the time of bypassing the unit steam is not tied up to any particular instant after fans have been shut down and dampers drawn. There is practically no danger of condensation in the boiler even if bypassing is delayed after the operation of letting down.

At Columbia separate reheat boilers are also installed, the following paragraphs taken from an N. E. L. A. report giving an idea of the time required when putting a reheat boiler on the line in cold condition: "At 4:40 two middle horizontal burners were ignited. Shortly after this operation the drains on the reheat piping and valves and the bypass valve on the 26-in. main reheat valve were opened. This operation allows the steam to circulate through the reheat piping and coils. Observation of the trap discharges and open drains from the piping serves as a guide to tell the operator how long the warming up period will last. When the pressure in the reheat piping and coils becomes equal to the high pressure turbine inlet and the drains indicate that condensation has stopped, the 26-in. inlet valve is opened. This occurred at 5:38. At 5:42, the 30-in. reheat valve was partially opened and was fully opened at 5:47.

"Up to this operation it is essential to maintain the proper temperature conditions in the boiler. It has been found that the temperature of the gases entering the reheater should not be allowed to exceed 550 deg. during this period. Should the gas temperature exceed this value to any extent the steam within the reheater coils would become highly superheated and cause a rapid temperature change at the inlet to the low pressure turbine when the reheated steam is cut in.

"After the 26-in. and 30-in. reheat valves have been opened, the two 15-in. main reheat bypass valves are slowly closed. This operation was completed between 5:48 and 5:52. While these valves are being closed, the fireman must gradually bring up his fire to maintain the proper steam temperatures. The boiler was brought up to the full load reheat condition in approximately 3½ hr. The steam temperature entering the low pressure turbine shows a gradual increase in temperature from the time the main bypass valves are closed until the maximum temperature of 720 deg. F. is reached. Temperature changes of the steam inside the reheater are not rapid due to the large mass of metal in the reheat coils."

Improved Voltage Regulation

Improved voltage regulation on many of the rural feeders of the Niagara, Lockport and Ontario Power Company has been attained by installation of the recently announced General Electric step-voltage regulators for rural service. The first regulator, obtained in April, was installed with a minimum of time and expense because of its compact arrangement and built-in automatic features.

Regulation on the Panama section of the feeder, seven miles from the step regulator, has been improved from approximately 5.5 per cent to 1.8 per cent; on the Niobe section, eight miles from the regulator, from 5.6 to 1.8 per cent; and on the Blockville section of the feeder, two and one-half miles from the regulator, from 3.6 to 1.8 per cent.

Subsequent to this initial installation, the power company purchased two additional step-voltage regulators which are now about to be installed. In the layout for all new and revamped existing rural substations, the company is providing space for not only an automatic reclosing feeder breaker but also a step-voltage regulator.

Industrial Power and Steam Supply for Industrial Establishments

TRUE ECONOMY OF INVESTMENT AND OPERATION CAN USUALLY BE HAD ONLY BY PARALLEL OPERATION OF THE UTILITY WITH INDUSTRIAL EQUIPMENT

BY GROVER KEETH*

TIME WAS, and it is no doubt the case today with many in the power sales field, when it was considered that the only good isolated generating plant was one that was shut down. This idea was probably partially due to the fact that the power salesman knew little of the manufacturers' problem and the industrial manager of the plant knew little about what happened to his steam and power after it was made. Kilowatts being invisible the manager could not visualize them and rather felt the money it cost to operate his power plant was an unnecessary expense.

My opinion is that fundamentally no industrial establishment having a reliable source of power available has any business generating a kilowatt hour from which they cannot use the exhaust steam and, conversely, no utility has any business selling a kilowatt hour to an industry if the exhaust steam from that kilowatt hour could be used in process work. In other words, true economy of investment and operation can only be had by parallel operation of the utility with non-condensing, or, perhaps bleeder equipment, in the industrial field as this plan reduces capital expenditure by both parties.

ELECTRIC POWER

To my mind the sole purpose of a boiler room in an industrial plant is to produce B.t.u.'s in usable form. If on their way to be used these B.t.u.'s can produce some kilowatts, well and good, if they cannot then they probably shouldn't have been produced. Figures to support these general conclusions must be drawn from a specific industry. For this purpose paper, which ranks sixth among the major industries and is one of the oldest manufactured articles used by man, has been chosen.

Division of cost by percentage in the manufacture of paper mill products might be as shown by the accompanying tabulation:

DIVISION OF COST IN PAPER MAKING

Raw Material	50.0%
Labor	14.0%
Power	3.9%
Steam for processing and heating	8.9%
Miscellaneous materials and maintenance supplies	1.1%
Operating supplies (including machine cloth, wire, etc.)	3.2%
Plant overhead or factory burden (consisting of insurance, depreciation, taxes)	12.2%
General administration and selling expense	6.7%
Total	100.0%

Paper is now largely made from wood and can be divided into two general groups, that made from mechanical pulp and that made from chemical pulp. Mechanical pulp or ground wood is generally spruce that has been reduced to pulp by means of revolving grindstones in the presence of water. This pulp is used for cheap papers such as newsprint, filler for certain grades of cartons and shipping boxes. For newsprint about 15 per cent of chemical pulp must be added as a binder. To produce a ton of air dry ground wood pulp requires 900 kw-hr. It is obvious that with this large amount of power, a ground-wood mill must be located near a cheap source of power.

Two kinds of chemical pulps commonly made in Wisconsin are sulphite and sulphate and the initial step in their preparation is the same. Sulphite paper is used for business purposes, paper napkins, tablecloths and fancy wrapping paper while sulphate or kraft is the wrapping paper commonly used in business. Power required to make a ton of finished paper in a sulphite mill from log to sealed package or loaded car is about 755 kw-hr. divided, 360 for the pulp manufacture and 395 for the paper manufacture.

STEAM FOR SULPHITE PAPER

Average steam required to make a ton of finished sulphite paper is 25,000 lb. of which about 40 per cent is used for digesters, 15 per cent for bleaching, 3 per cent for beating and 42 per cent for drying. There is a seasonal variation of about 35 per cent due to building heating requirements, warming up raw materials and so forth.

In a chemical pulp mill power is first required for handling the logs, in the raw mill, barker, chipper and screens. The wood is then cooked in the digester using about 6500 lb. of steam per t. of pulp at a pressure of from 90 to 110 lb. The demand for steam in this process is extremely erratic ranging from nothing to 30,000 lb. per hr. in a few minutes and dropping off just as rapidly. From the pressure requirement it is evident that bleeder steam cannot be used economically unless the boiler pressure is approximately 400 lb. In the sulphite process the wood is cooked with acid for 10 to 12 hr., while in the sulphate process alkali is used and the cooking period is only about 4 hr.

Bark removed from the logs and refuse from the raw mill although running around 50 per cent moisture is usually used as fuel, the heating value as fired running around 4000 B.t.u. In the case of sulphate mills the cooking process produces a by-product fuel. The chemicals used are recoverable and the residue, which contains the lignin dissolved from wood, has a fairly good heat value. Waste liquor from the sulphate process is very dilute and costly to reclaim.

After cooking, the pulp must be washed and screened to free it from acid and dirt, bleached and again washed.

*Marathon Paper Mills Co., Rothschild, Wis. From a paper presented before the Great Lakes Power Club at Milwaukee, Wis.

These steps require considerable power, mostly for pumping, but no steam beyond that for building heating. The pulp is then run through the heaters and jordans, requiring the greatest amount of power of any single step but only a small amount of low pressure steam for warming up the beaters in the winter.

On the paper machine the sheet is formed and the moisture reduced to 60 to 70 per cent before passing through the drying rolls where the moisture is reduced to 5 to 6 per cent. Dryers are heated with steam and require a little more than the digesters. From the dryers the sheet is smoothed by passing through a calender stack and then wound into rolls.

Our mill, which has a capacity of 150 t. of finished paper per day, including the manufacture of 110 to 115 t. of pulp per day, requires an electric supply of about 4000 kw-hr. which remains fairly constant from a few hours after the mill has been started on Monday morning until shutting down on the following Sunday morning. The steam load average is 4000 b.hp. in summer time and 4800 in winter with occasional peaks as high as 5300 b.hp.

A few years ago I spent some time investigating high inlet pressure steam turbines with high back pressure to make use of the steam required by the digesters but had to drop the matter because there was no place for power to go when the river was performing as it was supposed to. Trying to work out a heat balance with low head power is extremely difficult. Probably 1000-kw. could have been produced by the steam used by the digesters and steam blown into the low pressure steam system, had there been any place to put the power. It is for this reason that I say true economy of power production cannot be obtained until there is an interchange of power between an industry requiring power and a central station system.

High Pressures

On the subject of higher steam pressures in paper mills I am rather hesitant to say much as I feel it will be productive of considerable discussion. So far as I know such a discussion would only be a presentation of opinions rather than facts. What I shall give you is my opinion, therefore, based on both personal experience with pressures up to 350 lb., contact with neighboring mills operating at 400 lb. and a utility plant operating at 1400 lb.

The primary purpose of a boiler plant in a paper mill as I have already stated should be the production of B.t.u.'s in usable form, placing continuity of operation and first cost ahead of high efficiency which I feel can only be obtained by complicated equipment. The first step in determining a suitable working pressure is to make up a heat balance for the mill, that is to estimate as closely as possible the heat required for the several operations involved in the manufacture of the company's products. Next, find out how much heat can be recovered from return condensate, hot air and vapor discharged from machine hoods, etc. Probably a portion of this heat can be used for some purpose as heating process water instead of using steam direct.

After the heat requirements have been determined, estimate the power requirements and from the heat requirements previously figured, determine at what throttle pressure, preferably using standard apparatus, would produce the greatest number of kilowatt-hours. It is not very often that these can be made to balance. If a mill is making paper from old papers, I have, for two different mills, worked out a balance with 300 lb. at the throttle and 20 lb. back pressure.

For conditions as they exist today in a mill making its own sulphite pulp, I personally do not see any need for a higher steam pressure than 400 lb. If the mill has a purchased power connection, as it should have, I would then install a turbine operating against 20 lb. back pressure with a bleed point somewhere around 150 lb. for supplying steam to the digesters. A new method of cooking has been successfully used and as soon as more information is available on this development, I strongly suspect that a workable heat balance can be obtained by using pressures not to exceed 200 lb.

Power Factor

There are two other points to be considered in making a study of steam pressures. First, what is the probable usable life of the boilers already installed, and second, what changes are liable to come about in the process of making the particular article in question, or, how soon will the public decide that they do not want the article you are now making but want something else.

If we are to consider interchange of power, we must look to our power factor. I find that in the average paper mill this is very poor due to the large use of induction motors which is the case of beaters, run underloaded a portion of the time. Also many motors are too large for the service required of them. It frequently happens that when a motor burns out due to some mishandling it is immediately assumed that the motor is too small and a larger motor is put in its place. It is only recently that paper mill operators have started to give closer attention to this point and also to the careful installation of equipment which requires less power consumption.

Locomotive Pinch Hits for Dairy Boiler Plant

Recently a serious boiler explosion occurred at the plant of a dairy products factory causing the death of one man and injuring two others. The steam plant of the dairy company was badly damaged. There were three boilers in the plant, the center one of the battery being the one that exploded. The explosion caused a shifting of the other two boilers, breaking of steam and water lines, wrecking of foundations, shifting of walls and breaking of all windows in the boiler house.

Recently the company had contracted for the installation of automatic stokers, one of which was in operation on one of the boilers and the installation on the boiler that blew up had just been completed but was not in use. The boiler on which this one was installed had not been in use. A light fire had been built under the boiler to dry out the masonry and the plans were to start this boiler later.

While repairs were being rushed a railroad locomotive pinch-hit as a furnisher of steam.

W. F. Schaphorst.

GANG Bonus System Cuts Fuel Costs in Half

DENVER TRAMWAY CO. REWARDS POWER PLANT EMPLOYES ON EQUAL BASIS FOR ECONOMIES EFFECTED.

BY LUCIUS S. FLINT

OVER A PERIOD of a number of years, the Denver Tramway Co., Denver, Colo., has saved thousands and thousands of dollars on power production costs through the use of a novel gang bonus system which gives employes a strong incentive for helping to hold down fuel consumption. When the system was adopted, consumption was averaging 5 lb. per kw-hr. It immediately dropped to 2½, and has stayed there almost continuously.

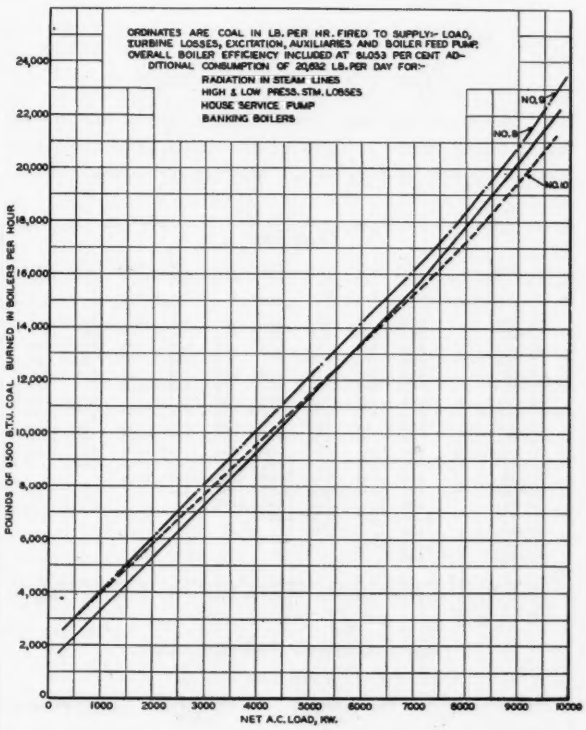
The system is so worked out that every man benefits when power production expense goes down—and suffers when the cost increases. Because any lack of efficiency in the plant means a cut in income for all employes, every man makes it his personal concern to see that everything is as it should be. As a result, steam leaks are virtually unknown in the power house, all machines are kept in the best of repair and every other phase of operation is kept "up to snuff".

"In our experience, the only way to keep power production costs down to the absolute minimum is to get the full coöperation of the men," says N. R. Love, chief engineer for the company. "The little savings here and there pile up at the end of the month, and these savings are largely in the hands of the employees. Obviously, a bonus system will do more to get their coöperation than will the strictest kind of supervision because each individual is personally affected.

"Our system gives the men an unusually strong incentive for exercising care, for the reason that the more the men save the higher is their percentage of the saving.

"In the first place, we calculate the theoretical consumption, based on the hours of operation and the load for each unit. We begin to pay a bonus when the actual coal consumption is 0.6 lb. per kw-hr. greater than the calculated base. The bonus increases rapidly as the amount of coal saving is increased. It reaches a maximum when the actual consumption is 0.1 lb. per kw-hr. less than the calculated consumption. At the present time, the maximum is $631, which amount is divided equally between all of the power house employees in the boiler room and the engine room. Amounting to about $25 per man each month, the bonus is something well worth working for. The power house people occasionally reach the maximum, and are always very close to it. Because of conditions, the bonus was recently cut in half, but the figuring is not changed.

"Our system was developed after making a careful study of past production records, which showed us two things: what the consumption could be brought down to and what the average was. It became evident that the company could cut power costs only to a certain point without the help of employees. Obviously, this point would vary considerably in different plants. The maximum represents what is about the best performance which could be secured at this particular plant at the load and load factor imposed upon it.



COAL CONSUMPTION PER HOUR FOR PLATTE ST. POWER HOUSE UNITS NOS. 8, 9 AND 10

"The theoretical coal rate was based on a careful investigation—which extended over a period of several months—of all losses in the plant. These losses can be classified briefly as follows:

a. Losses proportional to time of operation (or time not operated)

1. Radiation from boiler settings.
2. Auxiliaries.
3. Windage and friction of apparatus.
4. Station light and heat.
5. Radiation in piping.
6. Field loss in generators.
7. Loss in condensate.
8. Steam leaks.
9. Banking boilers.

b. Losses proportional to output.
   1. Ash loss.
   2. Stack loss.
   3. Friction in pipes.
   4. Heat returned to cooling water.
   5. Coal handling.

c. Losses proportional to square of root-mean-square output.
   1. Generator armature copper loss. (This is such a small proportion of the total loss that it may be assumed as proportional to output without appreciable error.

d. Unclassified.
   1. Waste steam.

How the Bonus Is Figured

"The time operated and the total gross output are the starting points in figuring the bonus. The gross load divided by the time gives the average gross load. From this figure are deducted the auxiliaries to get the net load. The net load for each machine applied to the performance curve illustrated gives the pounds of coal per hour for that engine.

"It may be seen that our graph shows the coal consumption per hour for each of three units. The ordinates scale, from zero to 24,000, represents the number of pounds of 9500 B.t.u. coal burned in the boilers per hour. The abscissae scale represents the average load on an engine, or the kilowatts per hour. The abscissae are scaled from zero to 10,000.

"After obtaining from the graph the number of pounds of coal per hour, we calculate the total coal, and then the coal per kilowatt-hour. The February calculation shown is a good example.

"The accompanying table shows us the amount of the bonus to be paid, based on the relation between the actual coal consumption per kilowatt-hour and the theoretical coal consumption as calculated above. The vertical column at the left hand side of the table shows the pounds of coal per kilowatt-hour. The nine columns to the right give the base ranges. Because of the great number of classifications necessary, both kilowatt-hours and base rates are combined in pairs. Points lying between these sets of figures are easily estimated. Of course, the final amounts can be calculated by equation, but the table saves an unlimited amount of time in getting out the monthly reports. The equation used is as follows: x equals the base lb. coal per kw-hr. minus the actual lb. coal per kilowatt-hour; y equals the bonus in dollars. Then, y equals 2500x squared plus 3050x plus 932. However, y shall be not less than zero nor more than $1262.

"The bonus is figured monthly, the amounts of coal being taken from the mine weights as compiled by the auditor, and the kilowatts being taken from the switchboard reading."

BASE RATE*

Lb. Coal Per kw-hr.	243-245 $	245-247 $	247-249 $	249-251 $	251-253 $	253-255 $	255-257 $	257-259 $	259-261 $
271-269	308	344	382	422	464	508	554	602	652
269-267	344	382	422	464	508	554	602	652	704
267-265	382	422	464	508	554	602	652	704	758
265-263	422	464	508	554	602	652	704	758	814
263-261	464	508	554	602	652	704	758	814	872
261-259	508	554	602	652	704	758	814	872	932
259-257	554	602	652	704	758	814	872	932	994
257-255	602	652	704	758	814	872	932	994	1056
255-253	652	704	758	814	872	932	994	1056	1124
253-251	704	758	814	872	932	994	1056	1124	1192
251-249	758	814	872	932	994	1056	1124	1192	1262
249-247	814	872	932	994	1058	1124	1192	1262	
247-245	872	932	994	1058	1124	1192	1262		
245-243	932	994	1058	1124	1192	1262			
243-241	994	1058	1124	1192	1262				
241-239	1058	1124	1192	1262					
239-237	1124	1192	1262						
237-235	1192	1262							
235-233	1262								

*Although the bonus has been reduced 50 per cent, this table is still used, the final total being just cut in half. The change was made to meet the need for greater economies.

SAMPLE CALCULATION OF POWERHOUSE BONUS

Feb. 1933

Unit No.	Time Operated	Total Gross Output	Av. Gross Load
8	194.83 hr.	1,046,000	5368.7
9	378.33 "	1,502,100	3970.3
10	194.16 "	686,500	3523.7
Total	572.49 hours 9 and 10 units in service		

Auxiliaries: 73,400 kw-hr. $\frac{73,400}{572.49}$ = 128.2 kw-hr.aver.auxiliary load

Net kw-hr.: 1,046,000 plus 1,502,100 plus 686,500 minus 73,400 equals 3,161,200 kw-hr. net.

Unit No.	Av. Gross load kw-hr.	Av. net load	Lb. coal per hour	Lb. coal total
8	5,369	5,369	12,020	2,341,856
9	3,970	3,842	9,703	3,670,935
10	3,536	3,408	8,505	1,651,330
Coal for other purposes (20,632 times 28)				577,696
		Total lb. coal		8,241,817

Base rate: $\frac{8,241,817}{3,161,200}$ = 260.7

Actual coal per kw-hr.: Coal consumed 4,065.7 t. less credit steam furnished outside users, 6.68 t., equals 4,059.02 t. equals $\frac{8,118,040}{3,161,200}$ equals 256.8.

Bonus: Base rate, (259-261) Coal rate (257-255) equals $529.

TABLE USED IN CALCULATING BONUS

Use of Very Fine Slack Saves Money

The Tramway power department has also made a sizeable saving in fuel expense through the use of a very fine slack commonly known as "bug dust". The mixture in use contains about 20 per cent "bug dust", along with regular slack and lump. The "bug dust" is mixed with other sizes at the hopper so that the proper "blend" is obtained.

It has been found that this material really improves the mixture if it is used immediately after being received. Use of the product naturally means a much lower fuel cost, because it has almost no market value.

Maintenance costs in the power plant have been cut to some extent by the adoption of a novel budgetary system. At the beginning of each month, the superintendent of the power plant submits to the president of the company an estimate of costs for the period. An appropriation based on this recommendation, but in line with what the property can afford to spend for the department, is made, and three times during the month the superintendent turns in reports showing actual expenditures to date. These reports help the department heads to apportion their expenditures to best advantage, and to keep within a figure in line with revenue.

Speeds must be accurate in a steel rod mill which rolls a bar 2 to 3 in. square and 30 ft. long into a mile of ¼-in. rod. The operation is continuous, the rod leaving the final rolls at a mile a minute while the bar enters the first rolls at a few feet a minute. Evidently any slip in speed adjustment will result in a red hot mess.

Control of Boiler Water Carryover

Both Chemical and Physical Factors Must Be Given Consideration. By H. T. Hotchkiss, Jr.*

CARRYOVER, priming, bumping and foaming are used very loosely so it is desirable to define them before proceeding. Carryover refers to the presence of liquid, transported by the steam as boiler water, in the steam mains, the composition of the carryover, of course, approximating that of the boiler water. Foaming exists when the boiler water surface is covered with a heavy froth or network of bubbles and under these conditions it is difficult to ascertain the exact level of the boiler water. Bumping occurs when the water at a heating surface becomes temporarily superheated and steam is formed with explosive violence. When boiler water is entrained in the steam and reaches the mains in abnormal quantities due to such conditions as bumping, jetting or foaming, the condition is termed priming.

There is a departure from the ordinary distillation process which goes on in the steam generating cycle, where carry over takes place. The mechanical entrainment of boiler water brings the composition of the steam above that minimum of dissolved and suspended matter which is associated with practical operation. In consequence solids may be thrown out in the superheaters, lines and prime movers. The evaporation of the water or carry over, in the superheater tubes, results in the formation of a residue of solids which can adhere and build scale on the superheating surfaces. These deposits are not only harmful from the point of view of decreased efficiency but actually introduce a hazard to the operation of the plant.

Scale in Steam Lines

Incrustation of lines and fittings due to the precipitation of solids originating in the boiler is particularly objectionable because the deposits are likely to be localized and grow rapidly. Steam lines are only freed from scale with difficulty and at considerable expense. Where solids accumulate in the steam passages of prime movers, efficiencies are unfavorably influenced and in the case of steam turbines, the presence of solids may be destructive as well for the erosion of blades by the impinging solids travelling at high velocity has a sand-blasting effect. Disastrous effects which may be occasioned by slugs of water carried by the steam, and the damage which may be occasioned if they reach the cylinders of steam engines, are too well known to need amplification.

Advances which have been made in boiler design to separate moisture from steam at the boiler have improved the character of the steam but there are still installations where excessive steam velocities exist in the neighborhood of the water level. The directional and localized liberation of steam incident to poor design may cause a jet at the water surface. Boiler water is thus thrown into the steam space and is swept over into the main. The proper arrangement of baffles and steam separators will influence the quality of the steam, one authority remarking, "It would seem that too broad generalizations should not be made because in some cases the boiler design profoundly affects the behavior." Dryness is therefore a function of design. Sometimes priming may be traced directly to dirty feedwater, overloading, oil or high concentrations of dissolved solids, so it goes without saying that boiler feedwaters should be as free of suspended matter as is reasonably practical and that there is a limit, beyond which trouble is to be expected. Even where filtering arrangements are available, there is no assurance that suspended solids are prevented from entering the boiler 100 per cent of the time. Where suspended matter is concentrated in the boiler, this is a factor in setting up conditions which induce priming.

Overloading a Cause of Priming

Priming due to overloading results from the fact that steam is generated in the boiler at rates which were not intended when the boiler was designed. The apparatus is thus pressed beyond its normal rating and the free liberation of the steam bubbles is hampered. The effects are in a manner similar to a sudden demand on the line which results in a drop in pressure within the steam space of the boiler. Here an increase in the rate of evaporation takes place and the boiling may be so violent that the steam carries over a spray of water.

Effect of oil on priming is related to its effect on the foaming characteristics of the water. The nature of the oil is an important consideration. In general it may be said that oils tend to stabilize the bubbles although castor oil is a notable exception which has been used by some as an anti-foaming agent.

To get a picture of what goes on within a boiler, take the case of operation under ordinary steaming conditions. At the heating surfaces the water is raised above its critical temperature at the pressure involved, and a change from the liquid to the gaseous state takes place. Steam appears in the form of bubbles. These are practically spherical in shape since the gas pressure within is equalized in all directions and may be evaluated as the sum of the boiler gauge pressure and the hydrostatic head of water above the particular location on the boiler plate or tube in question.

Since the steam is less dense than the water, the bubble rises after it becomes disengaged from the metal

*Feedwaters, Inc., New York, N. Y. Republication rights reserved by the author.

heating surface. As it rises it undergoes pressure and volume adjustments at the various liquid levels. At the steam-water interface associated with each bubble there is a tendency for adsorptive effects to take place in the surface film surrounding the bubble. When the liquid level of the boiler is reached, the steam bubble tends to raise the surface film which already exists there. Part of the liquid is thus stretched into a thin lamella, upon which a film again forms. The foaming tendency of boiler water is directly attributable to the specific character of this film.

Relation of Surface Tension to Foaming

A pure liquid does not give a stable foam. To obtain stability, tough amorphous surface films are necessary. In the first place, for stretching of the film to take place to any degree, the vapor pressure and surface tension must be sufficiently small. If the vapor pressure of the liquid within the film is high, evaporation will take place and the film will dissipate. If the surface tension is high the film will be disrupted because of the speed with which the bubbles break down due to the forces which seek to make the surface area a minimum.

In order, therefore, for the stretching of the surface layer to take place to any appreciable degree with any measure of stability, the surface film must act more or less as a physical skeleton supporting the bubble structure. This is afforded by the impurities which are adsorbed on the film. Naturally the evaporation from such a surface is less rapid, since it takes on the characteristics of a plastic solid rather than a liquid.

Now the character of the impurities present and concentrated in any surface will in large measure determine the specific nature of the foam which will be formed and the size, rigidity and durability of the bubbles which constitute the foam. In order to visualize just what is happening within a steam boiler, it is desirable to explore this subject further. Were it possible to maintain pure water within a boiler the difficulties due to priming and carry over would be practically eliminated. Since feedwater and boiler waters are contaminated, naturally or otherwise, however, the impurities therein and their effect on the surface films must be considered.

It has been demonstrated that fairly high concentrations of soluble salts may be tolerated without setting up bad foaming conditions in those cases where suspended solids are absent. Furthermore, a fair concentration of some suspended solids may be maintained where soluble salts are minimized, without encountering excessive foaming. The combination of suspended and soluble solids in the same solution makes carryover much more probable. In consequence, it may be said that a treatment which introduces a minimum of solids, and prevents unduly rapid concentration of suspended matter, will react favorably from the point of view of the control of carryover in a fairly well designed boiler. Under these conditions it will be unnecessary to resort to excessive blow down.

The mechanism of the carryover action is quite simple. The solids constitute at least a part of the supporting foam structure. If the foam is not physically carried into the line the bursting bubbles will throw a spray containing solid material into the steam space. Steam at high velocity, acting against the force of gravity, sweeps the solid materials out of the boiler to be deposited later within the superheaters, lines, turbines, prime movers, or returns. There are some who believe that carryover is to a certain extent selective, but any carry over is detrimental.

When the pressure in the steam space is reduced by a sudden demand for large volumes of steam, the water is temporarily superheated and a certain percentage may flash into steam. When finely divided suspended solids are present, these will act as nuclei for steam bubble formation, resulting in the appearance of a myriad of small bubbles throughout the body of the boiler water. The instantaneous foam thus generated may wipe out the water line entirely, fill the boiler with froth, and result in severe carryover.

It appears from the foregoing that physical methods of conditioning feedwater should have a beneficial effect on the quality of the steam generated. Under comparable conditions the boiler concentrations of both dissolved and suspended matter should be less under physical than under chemical treatment, resulting in drier steam with a minimum of carryover, with less blow down.

Oil Refinery Refrigeration

Refrigeration is extensively used in oil refineries for removing the wax or parrafine content from lubricating oils. After the gasoline and kerosene are removed from the crude oil the balance is treated with acid and clay. It is then filtered and mixed with naphtha and the solution at about 150 deg. is passed through

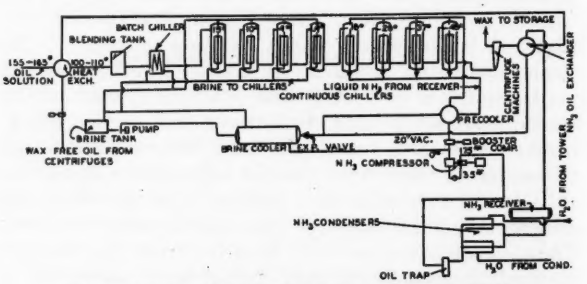


DIAGRAM OF REFRIGERATION IN A REFINERY

a heat exchanger into a blending tank after which the naphtha content is increased to about 70 per cent. The solution is then cooled in a batch chiller from about 100 to 25 deg. F. over a period of 15 hr.

If the oil is chilled too rapidly the waxes do not crystallize properly and in the plant illustrated the brine temperature is maintained about 10 deg. F. below the oil temperature with a chilling rate of about 5 deg. per hr. As shown by the drawing, the old solution leaves the batch chiller at 25 deg. F., is pumped through continuous chiller at rate of 95 to 100 barrels per hour. Four of these chillers are cooled by brine and four by direct expansion, refrigeration being provided by a 198 t. machine rated at 0 lb. suction, 195 lb. head pressure. Gases from the coils in the direct expansion chillers at a vacuum of 20 in. are delivered to the suction section of the main compressor at atmospheric pressure by a 60 t. single stage booster.

In the continuous chillers the oil is cooled in steps from 8 to 11 deg. to a temperature of minus 47 deg. F., and leaves the centrifugal at about —35 deg. F. after which it passes through a series of heat exchangers to cool the incoming oil supply.

Recent Developments in Exciters *and* Excitation Practice

By H. M. FRENCH, Industrial Engineering Dept. General Electric Co.

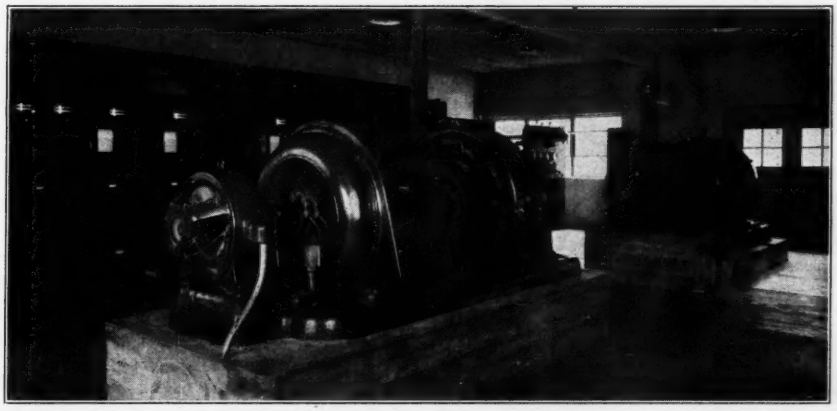


FIG. 1. MOTOR GENERATORS USED FOR POWER FACTOR CORRECTION IN A CEMENT MILL

DIRECT-CURRENT exciters, properly controlled, can be made to perform, or to assist other apparatus to perform, a number of operations. Synchronous motors, alternating current generators, and synchronous condensers are entirely dependent on a source of d-c. excitation for successful operation. The success of large, complicated control systems may, in many cases, be attributed directly to small direct-current generators which are so overshadowed in size by the large apparatus that they are entirely lost from sight.

This article describes some of the latest developments in the methods of furnishing and applying excitation and give some examples of their practical use.

Excitation current for synchronous motors is usually furnished in one of three ways; by a direct-connected exciter, a belted exciter, or a motor-generator set. High speed motors, that is, those operating at 514 r.p.m. and higher, are usually furnished with direct connected exciters. Belted exciters or motor-generator sets are usually furnished with low speed motors, 450 r.p.m and below, the belted exciter being generally more economical down to approximately 180 r.p.m.

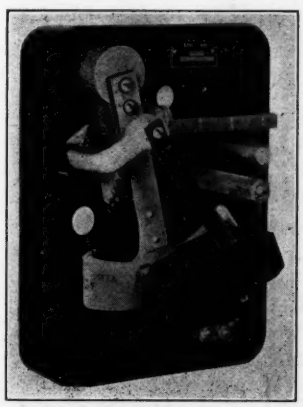


FIG. 2. POWER FACTOR FIELD REMOVAL RELAY WITH COVER REMOVED

Modern synchronous motor controllers provide automatic means for applying and removing excitation at proper times. New relays for accomplishing this have been recently developed.

For each synchronous motor installation there is a minimum speed which must be attained in starting before the motor will synchronize when field excitation is applied. The speed depends upon the nature of the driven load and upon the motor characteristics but for most applications it will fall within the range of 95 to 98 per cent of synchronous speed. If field is applied before the minimum required speed is reached, the motor will fail to synchronize and a heavy pulsating current will be drawn from the line. On the other hand, failure to apply excitation will mean that the motor will continue to operate as an induction motor with low efficiency, low power factor, and high line current. Therefore a device for properly applying field excitation should be sensitive to small changes in motor speed.

In order to provide automatically for proper application of field excitation, modern synchronous motor controllers are now equipped with a slip-frequency field-application relay. This is a simple yet sensitive device which responds to a definite slip frequency which will not occur before a definite speed is reached. The operation of this relay is independent of the magnitude of the induced field current or line voltage. Adjustment is provided so that the relay can be made to operate at any predetermined speed between the limits of 92 and 99 per cent of synchronous speed.

The coil of this relay is connected across a section of the discharge resistor and in series with a half wave copper-oxide rectifier. During the starting period, induced field current flows through the discharge resistor at slip frequency but only half waves of current flow through the relay coil since the rectifier permits current to flow in but one direction. The relay coil is provided with a copper jacket which gives the relay a definite time lag in closing its contacts so that they will hold open as long as the time intervals between the half waves are less than a certain definite value. However, when the

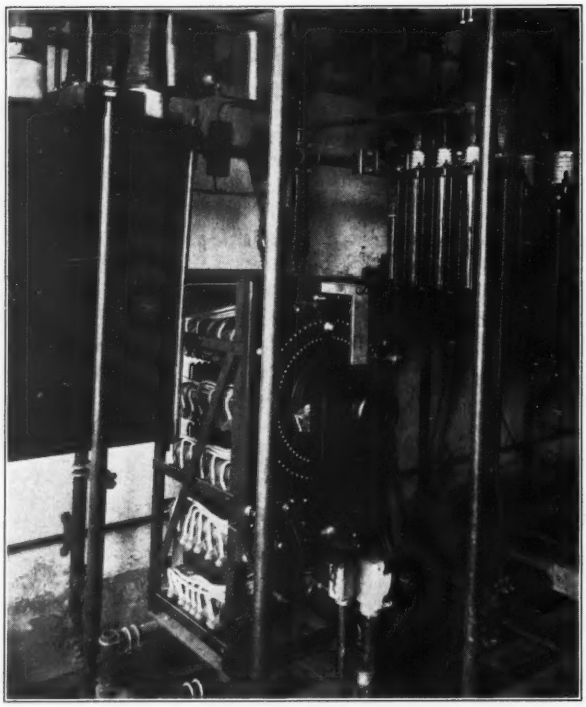


FIG. 3. MOTOR OPERATED RHEOSTAT THAT INCREASES OR DECREASES THE CURRENT IN THE FIELD OF THE SYNCHRONOUS MOTORS SHOWN IN FIG. 1

speed is increased to a point where a time interval between successive half cycles of current is just greater than the time lag of the relay is reached, the contacts close and field excitation is automatically applied.

Automatic Removal of Field Excitation

When a synchronous motor pulls out of step, either because of an excessive dip in line voltage or a high momentary overload, field excitation should be removed immediately in order that maximum torque be delivered and the severe line current pulsations which accompany out-of-synchronism operation with field excitation applied, be eliminated.

A new relay for automatically removing the motor field excitation when the motor pulls out of synchronism is called the power-factor field-removal relay. Its operation depends on the power-factor of the current drawn by the synchronous motor.

Under normal operation a synchronous motor operates at unity or leading power factor. Even under the maximum overload which the motor can carry in synchronism, the power factor does not fall below 70 per cent lagging. However, if the motor is pulled out of step either because of a severe dip in line voltage or excessive overload, the power-factor drops abruptly to a low lagging value.

The design of the power factor relay is such that it remains closed if the motor power factor is leading unity or not less than 60 per cent lagging. If the motor power factor drops below 60 per cent lagging, however, the relay contacts will open and remove field excitation. Hence, this relay will remove field only when the motor pulls out of step. Under such conditions, it operates to remove field immediately, that is, during the first slip-cycle out of synchronism. This prompt removal of field very frequently allows the motor to resynchronize when the voltage returns or the overload is removed where it would otherwise come to a bothersome standstill.

Applications

In an industrial plant in the Middle West a synchronous motor-driven motor-generator set is used to hold the power factor of the plant at unity by varying the field current on the synchronous motor. This plant was offered a very attractive power rate contingent upon their being able to schedule the operations of their plant so as to limit heavy power demands to off-peak periods, and upon their ability to maintain unity power factor at the plant. The motorization scheme in the plant involved a small number of direct current motors for adjustable-speed drives, in induction motors for the great majority of machines and synchronous motors for most of the large power units.

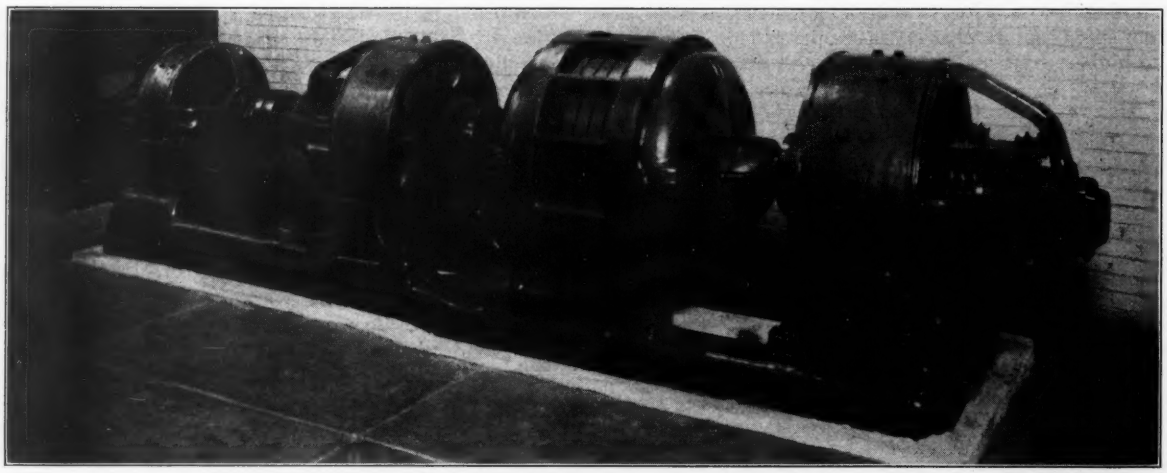


FIG. 4. FOUR-UNIT MOTOR GENERATOR SET USED FOR EXCITATION SERVICE IN A STEEL MILL

The d.c. unit at the right furnishes excitation for a 7000-hp. blooming mill motor. The unit second from the left excites the fields of the two 3000-kw. generator furnishing power to the blooming mill motor and the unit at the extreme left furnishes power for the fields of the other two exciters on the set.

Direct current motors and the excitation power requirements of the synchronous motors made up a direct current load of 300 kw. To supply this direct current, a motor generator set was installed, consisting of a direct current generator rated 300 kw., 250 v.; a synchronous motor rated 750 kv-a. 2200 v. and a direct-connected exciter rated 10 kw. 125 v. Control equipment consisting of a power factor relay, secondary relays actuated by this power-factor relay and motor-operated field rheostat with resistance, was also installed. A potentiometer with an adjusting handle permits adjusting the power factor condition from 0.95 lagging to 0.95 leading.

In event of lagging power factor the power factor relay is deflected to one side and closes contacts that actuate one of the secondary relays. This latter relay closes a circuit through the field of the direct-current motor operating the field rheostat. This reduces the resistance in the rheostat circuit and strengthens the field of the synchronous motor through its direct connected exciter. The leading reactive kv-a. supplied by the synchronous motor increases until sufficient leading reactive kv-a. is derived to bring the plant power factor to unity at which point the power factor relay again assumes a neutral position. This mechanism can also be operated in the reverse direction to counteract leading power factor conditions. If, at any time, it is desired to maintain a plant power factor other than unity, an adjustment of the potentiometer handle shifts the condition under which the relay remains in a neutral position. The motor-generator set used for this work is shown in Fig. 1.

Steel mills make use of a system for holding rolling mill motor speeds to one per cent or less by the use of small counter-e.m.f. generators used as auxiliary exciters. The speed regulating system embodies vibrating balenced voltage relays. Each of the rolling mill motors drives a separately excited direct-connected pilot generator, the armature current of which goes through a fine manually operated and coarse motor-operated field rheostat to one coil of the balanced relay. The opposing coils of all of the relays are in series across the 250 v. excitation bus. For each of the main rolling mill motors there is a counter-e.m.f. generator whose field is across the vibrating contact of the relay and whose armature current opposes the current in the main motor field, to the extent of 60 v. or less as required. Should any one of the rolling mill motors tend to increase its speed, no matter how slightly, its pilot generator will strengthen its coil on the balanced relay, this cuts all the field off the counter-e.m.f. generator, thus taking the opposition out of the motor field circuit. The resulting stronger field on the main motor brings its speed down, the pilot generator weakens the regulator coil and balance is again restored. The counter-e.m.f. field circuit is actually made and broken very rapidly, the opposition of the counter-e.m.f. generators varies rapidly and the speed is held within the specified limits at all times.

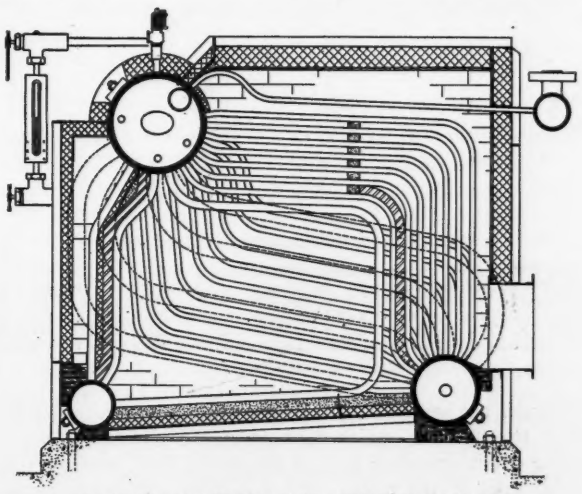
A number of different exciter combinations are used for reversing mill drives. For instance, a blooming mill drive consisting of a 7000-hp. reversing motor furnished with power from two 3000-kw. d.c. generators, would have a separate differentially compounded exciter for the reversing motor, another exciter for the two generators and a separate exciter for exciting the first two and for control power. The excitation of the 7000-hp. motor is controlled through the exciter field; that of the two 3000-kw. generators—directly, but the excitation of the generator exciter is automatically strengthened when the speed of the flywheel motor generator set drops down.

In order to take care of various loadings which tend to cause speed changes, the motor-generators used with modern high-speed elevators are provided with an extra unit, known as a series exciter. The field of this exciter is connected in series with the armature of the traction motor and its armature is in series with the shunt field of the generator supplying power to the traction motor. As the load on the elevator increases, and the speed of the elevator tends to fall off by reason of the drooping characteristics of the units involved, this small exciter boosts the strength of the generator field approximately in proportion to the sum of the various drops. As the overhauling load increases and the elevator tends to speed up, the exciter bucks the generator field approximately in proportion to the rise in speed. The elevator thus runs at approximately normal speed at all loads.

Steam for Process Heating

PROCESS STEAM at 715 lb. gage (saturated steam temperature 507 deg.) is furnished by a special oil fired boiler recently built by Foster Wheeler Corp. The high cost of the boiler for this service is largely offset by the simplicity of the installation and absence of the accessory equipment usually necessary.

No feed pump nor circulating pump is used as the boiler is placed immediately below the processing vats



SECTION THROUGH THE PROCESS BOILER

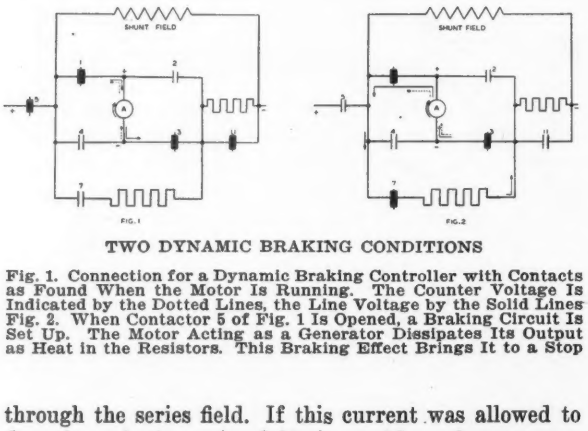
which contain the heating coils. These heating coils act as a condenser and condensate returns by gravity to the boiler. There is no make-up so the boiler can operate indefinitely without replacing the supply of water and since the volumetric capacity of heating coils is small, there is little fluctution in the water level in the drum.

The three drum boiler is built around a water cooled furnace and all the tubes within the setting are steam generating tubes, circulating tubes are placed outside the setting similar to water wall downcomers in order to assist the circulation.

Dynamic Braking

STORED UP MECHANICAL energy in a rotating motor can be converted into heat either directly by a friction brake or by first converting it into electricity and then into heat in an external resistor. Either method brings the motor to a stop; but the latter method, called dynamic braking, does it with less wear and tear on the apparatus.

Dynamic braking is applied most commonly to shunt-wound or compound-wound direct-current motors. It is possible, however, to apply it on other types of motors. In the case of the direct-current motor, braking is secured by first disconnecting the motor from the power supply and then connecting it to an external resistor circuit. The counter e.m.f. or voltage generated in the motor armature by its rotation in the magnetic field produces a current in the resistor circuit. This current reacts with the magnetic field of the motor in such a direction as to produce a retarding torque. The energy delivered into the circuit appears as heat in the resistor. The direction of the counter e.m.f. is opposed to that of the line voltage. Therefore the braking current is in a direction opposite to that of the current when the motor is delivering power and should therefore not pass



TWO DYNAMIC BRAKING CONDITIONS

Fig. 1. Connection for a Dynamic Braking Controller with Contacts as Found When the Motor Is Running. The Counter Voltage Is Indicated by the Dotted Lines, the Line Voltage by the Solid Lines Fig. 2. When Contactor 5 of Fig. 1 Is Opened, a Braking Circuit Is Set Up. The Motor Acting as a Generator Dissipates Its Output as Heat in the Resistors. This Braking Effect Brings It to a Stop

through the series field. If this current was allowed to flow through the series field, it would produce a magnetic effect opposing that of the shunt field, weaken the total field of the motor, and result in reduced braking torque. In some cases the result would be an entire loss of torque, if the series field strength was equal to that of the shunt field.

It is common practice to design the braking resistor to permit approximately full-load motor current to flow at the instant braking begins. The value of this resistor is determined by Ohm's Law. The counter voltage of the armature is approximately the same as the line voltage; the current value may be obtained from the nameplate reading of the motor. The energy loss is expressed by the formula E_2/R and therefore determines the capacity of the braking resistor.

Dynamic braking of synchronous motors is obtained by connecting a resistor around the stator winding after it has been disconnected from the power supply and while the rotating field continues to be excited. The alternating current so produced by the generator action results in the retarding torque and the energy disappears as heat in the resistor just as in the case of the direct-current motor.

Dynamic braking of squirrel-cage alternating-current motors is sometimes obtained by introducing a direct current into one or more phases of the stator winding. In this case the energy is not conducted to an external resistor but is dissipated entirely in a resistance of the squirrel-cage winding on the rotor.

Connections for dynamic braking of a shunt-wound motor are shown in Figs. 1 and 2. In Fig. 1 the contacts are shown in position in which they would be found if the motor were running. Dotted lines indicate the counter voltage set up by the armature rotating in the flux produced by the shunt field. If contact 5 is opened, Fig. 2, a braking circuit is set up. The motor now acting as a generator produces a current which flows in the direction indicated and passes through resistors. The energy stored in the armature during the accelerating period is thus converted into electricity and dissipated as heat.

As the name implies, dynamic braking is effective only while the motor is moving. It can be used therefore to stop the motor but not to hold it after it has stopped. For this latter purpose additional mechanical brakes are necessary.—ELECTRIC JOURNAL.

Modernization

SUBSTITUTION OF MODERN core and coils in three transformers of the Cumberland County Power and Light Company of Maine recently made it possible to use transformers on hand which otherwise would have been unsuitable for the service demanded.

The transformer bank serving the Old Orchard territory was inadequate. Elsewhere on its system was an installation of three 833-kv-a., 38,100 to 11,000-v. transformers which were too small for the service. For these the company substituted three idle 1250-kv-a. transformers already on hand. The 833-kv-a. units were then modernized to fit the operating conditions at Old Orchard Beach. Studies by General Electric engineers showed that the substitution of modern core and coils would increase the capacity to 1000 kv-a., permit a change to correct voltage, namely, 37,000 to 2400 v. delta or 4150 v. Y, with a 2100-v. tap for temporary use, and at the same time greatly reduce the losses and increase the impulse strength.

As Old Orchard Beach is a summer resort, the load is very light for about nine months of the year, so that the no-load losses are of vital importance. A comparison of the old and new losses shows:

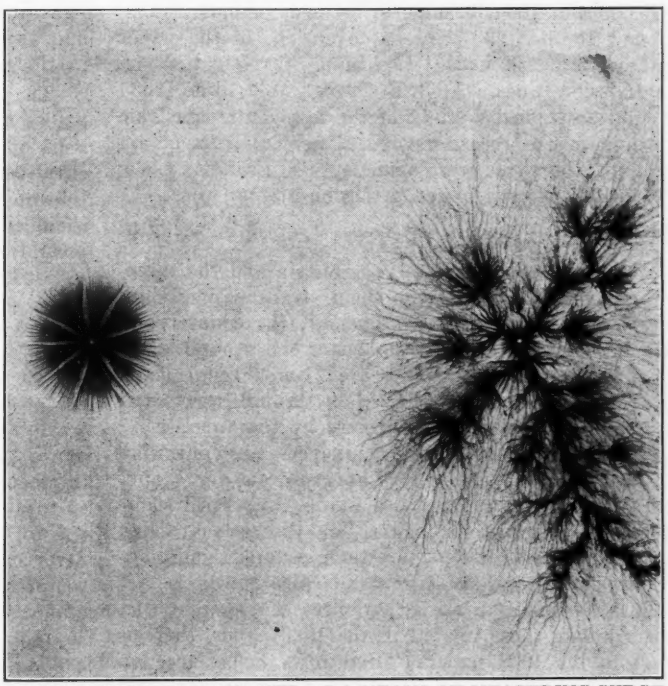
	No-load Loss	Total Loss Full Load
Tested losses of old units at 833 kv-a., in watts.....	6800	15650
Losses of old units computed at 1000 kv-a., in watts.....	6800	19600
Tested losses, modernized 1000 kv-a. transformers in watts..	3244	11686

The Romance *of* *LIGHTNING RESEARCH*

By EVERETT S. LEE

General Electric Co.
Schenectady, N. Y.

In this brief discussion, which was presented before the American Institute of Electrical Engineers recently, Mr. Lee in his characteristically interesting manner outlines what Engineers have accomplished in mitigating the damaging effects of lightning on electric power transmission lines.



LICHTENBERG FIGURES USED AS A MEANS OF MEASURING SURGE VOLTAGES

IN STUDYING the papers for the 1933 A.I.E.E. conventions, with particular reference to the symposium on insulation coördination, the session on lightning, and the session on the measurement of surge voltages, one is impressed by the great difference between the situation today and in 1925, which may be taken as the year when began the last romance with lightning by electrical engineers.

That was the year of many storms, made memorable by the wreck of the dirigible, "Shenandoah." In that year occurred the troubles described by Sindeband and Sporn in the first paper of the series which Mr. Sporn has presented ("Lightning and Other Experience With 132-KV Steel Tower Transmission Lines and Its Bearing on Tower-Line Design From the Continuity of Service Standpoint," A.I.E.E. Trans., v. 45, 1926, p. 770-90.) In that paper the authors say in their characteristic way: "While these troubles were occurring, it was impossible to get any accurate data as to what was happening. Lines were flashing over, insulators were being shattered, the conductor was being burned, the field forces were too busy trying to place the line in an operating condition with minimum delay to be able to give very much attention to the details of what was happening. Things were happening so thick and fast that there was no opportunity to stop and consider the matter calmly. With the approach of the end of the lightning season a little more time could be taken to determine what had actually happened to make an intelligent analysis." This graphic description undoubtedly finds a human response within all who at one time or another have found themselves in the midst of kindred troubles.

Coincidently with the need for analysis, which was evident generally, came the necessary tools, for in the A.I.E.E. Transactions of 1925 may be found a paper ("The Klydonograph and Its Application to Surge Investigation," v. 44, p. 857-71) delivered by Cox and Legg at the 1925 summer convention, Saratoga Springs, N. Y., telling of the klydonograph and the use of Lichtenberg figures as a means for measuring surge voltages. At the same convention, McEachron and Wade gave their paper ("Study of Time Lag of the Needle Gap," A.I.E.E. Trans., v. 44, 1925, p. 832-42) describing the application of the cathode ray oscillograph to time-lag studies of spark gaps technique in the same field.

Then started the romance of the engineers with lightning, and the wooing was furious. Out into the field they went on many different systems—east, west, north, and south, equipped with devices advancing year by year. Klydonographs and surge voltage recorders were dotted thickly along transmission lines to measure the voltages there. Up went the recorded voltages—1 million, 2 millions, 3 millions, 5 millions. The cathode ray oscillograph, laboratory instrument of the scientists, was taken out into its mountain home to await the coming of the lightning which the observers prayed would come in abundance and which the operators prayed would stay away with its devastation. But it did come and the cathode ray oscillograph, waiting, revealed the wave form of the voltages measured by the surge voltage recorders. This brought microseconds into the picture and engineers talked glibly on one microsecond and 10 microseconds, while yesterday

and today standardizations of these values are discussed with no more hesitation than the standardization of volts and ohms and amperes and degrees.

The romance continued. With the measurements of lightning voltages came the need for rating the severity of lightning, so the storms were counted, and the lightning severity meter was devised and used. Then came the wish to know more about the currents involved, and the lightning stroke recorder was developed; more instruments appeared along the transmission lines; talk of 50,000 and 100,000 amperes became common. Coming now to the 1933 winter convention, in the paper by Lewis and Foust ("Lightning Investigation on Transmission Lines," A.I.E.E. Trans., v. 52, June 1933) is found an intensive study of the tower currents from lightning stroke recorders and a new instrument referred to, the surge-crest ammeter (G. E. Rev., v. 35, 1932, p. 644-8) used for an extension of that work.

New Schemes Proposed to Offset Lightning Effects

With the gathering of all these data and the intensive analysis accompanying them, transmission engineers began to talk of new schemes; the counterpoise came into the picture to supplement the ground wire; lightning protection wires appeared; and through it all, the ground wire of old rode safely through the storm, being rendered even more effective by these devices.

New words came into prominence—rationalization coördination—and now these are subjects for standardization. Direct strokes and induced strokes became subjects of conversations, papers, and discussions; today the knowledge of these is more than certain, though apparently not yet subjects for standardization.

Turning again to the experiences recorded by Mr. Sporn, unlike those related in the 1926 paper, there is found in his 1932 paper ("Lightning Experience on 132-Kv Transmission Lines of the American Gas and Electric Company System," A.I.E.E. Trans., v. 52, June 1933) these words:

"The fact that comparatively few insulators, burned conductors, or hardware have been observed, and rarely of sufficient importance to require servicing, shows that the arcing protection has been very effective in preventing severe damage to the line. The protection afforded by the rings to line insulators is in line with prediction and past experience.

Outages Fewer These Days

"During the 3 years' operation, 1929-30-31, no trouble from lightning on the 132-kv lines has made necessary holding the line out of service longer than the time necessary to reclose the switch."

These are some of the results of the work which came after intelligent analysis. Of course, all problems have not yet been solved, but progress made toward that end is believed to be on a substantial basis.

In looking over some of the reports forming a basis of these papers, the following tabulation was found:

Year		Year	
1927	100	1930	100
1928	100	1931	70
1929	130	1932	50

No, these are not stock market indexes; they are storm severity records for one of the large transmission systems of the East based upon storm reports and line operation. Similar figure given by Mr. Sporn for his system do not show the same relative severity decrease in the last 2 yr., even though his line performance record shows more satisfactory attainment. These data are a necessary part of the whole picture in order that proper credit may be given to the design of the line and associated apparatus throughout in view of the line performance. There is still much room for advance in the design of instruments for recording lightning severity, and though the problem is difficult and the expense great, it is to be hoped that success in this regard ultimately will come.

Through all of this romance, there have been brought before many A.I.E.E. meetings and conventions the results of those who have worked so wonderfully and so effectively in this field. Their reward is their satisfaction of a work well done; at the same time due credit should be given the Institute which has made this forum possible.

Alcohol Blending of Gasoline

No material difference in fuel economy in the use of plain gasoline and of gasoline-alcohol blends in tractors operating on the belt or in the field and in motor trucks running on paved highways was disclosed in recent tests, reported the American Socieety of Agricultural Engineers. Sometimes the slight difference was in favor of plain gasoline; at other times, it was in favor of the blend. In the laboratory, tests in a high compression engine showed some difference in fuel economy and in power developed in favor of the blend.

Belt tests of a standard 4-cylinder tractor showed a maximum of 31.8 horsepower on plain gasoline and 31.6 on the 10 per cent blend, and little difference in fuel economy. When plowing, this tractor, working under practically the same conditions with both fuels, showed a fuel economy slightly in favor of gasoline. Belt tests of the same tractor fitted with high altitude pistons gave a maximum horsepower of about 30 with plain gasoline, further loading being accompanied with severe detonation. Use of 10 per cent blend increased the horsepower to 35; 20 per cent to 43.8, and 30 per cent to 44.4. The fuel economy with the 20 per cent blend was better than with plain gasoline.

A 2-cylinder, horizontal tractor engine on the belt delivered a maximum horsepower of 31.7 on straight gasoline and 32.2 on the 10 per cent blend, with a fuel consumption approximately the same. This tractor when plowing (under practically the same conditions with both fuels) showed a fuel economy slightly in favor of the blend.

After two ½-ton trucks of the same make and model, one running on gasoline, the other on 10 per cent alcohol blend, had each traveled approximately 2000 mi., the one with gasoline had average 15.6 mi. per gallon and the one with alcohol 14.6 mi. When the cylinder heads were pulled, considerably more carbon was apparent in the head on the engine burning plain gasoline. Octane ratings obtained on each of three plain gasoline averaged 66.6. On the gasolines mixed with 10, 20 and 30 per cent absolute alcohol, the ratings averaged 74, 79.6 and 84.6 respectively.

It Pays to Modernize Industrial Power Plants

By Norris D. Gove*

FUEL COST of the average industrial plant built 20 yr. ago can be cut practically in half by scrapping obsolete equipment and replacing it with the present-day design. Coal consumption in industrial power plants can be reduced about as follows:

1. New boilers and combustion equipment...10 per cent
2. Higher pressure and superheats.....16 per cent
3. Modern turbine generator units.....17 per cent
4. New turbine, alone.....13 per cent
5. Bleeding for feedwater heating..... 7 per cent
6. Repairs to equipment.....15 per cent

In certain applications, reheating also offers some savings.

Twenty years ago the combined efficiency of boilers and furnaces as shown by the published reports of tests ranged from 69 to 75 per cent. At present the range is at least 10 per cent higher for installations of industrial turbines. Furthermore, the new boiler permits higher pressures together with high-temperature feedwater heating and may also allow the use of cheaper fuel.

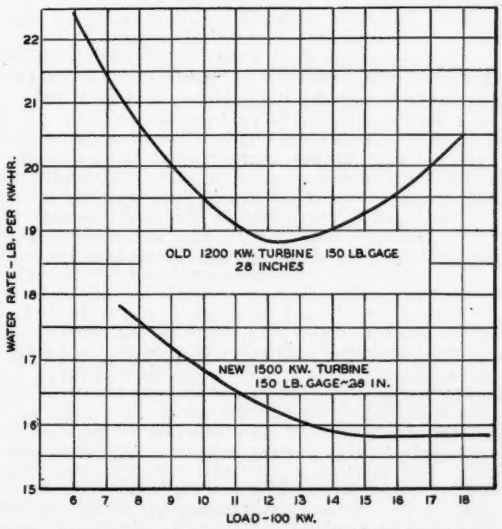


FIG. 1. WATER RATES OF OLD AND NEW TURBINES

Steam conditions of 400-lb., 700-deg. F. total temperature, are as common in new industrial plants as 150-lb. ga., 0-deg. F. was twenty years ago. Yet comparatively few realize that the higher conditions give an improvement in cyclic efficiency of 16 per cent (with 28 in. vacuum). This cyclic efficiency is transferred direct to the coal pile, as the 1932 model turbine for 400 lb., 700 deg. F. is slightly more efficient than its lower pressure brother. Plant managers need feel no hesitancy in considering the higher pressure for it is perfectly standard both for turbines and boilers. In fact,

*Turbine Engineer, Westinghouse Elec. & Mfg. Co.

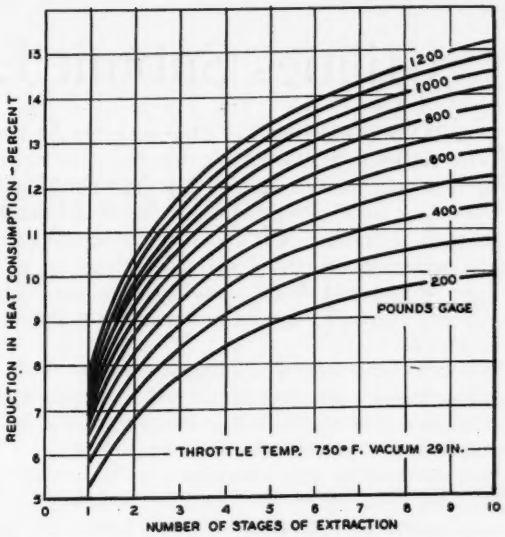


FIG. 2. REDUCTION IN HEAT CONSUMPTION WITH MULTI-STAGE EXTRACTION

considerable attention is now given to pressures of 600 and 1200 lb. with temperatures up to 850 deg. F.

The prime mover has kept step with other apparatus both in increased reliability and in improved performance. Turbines built this year are giving water rates 15 to 20 per cent (average about 17 per cent) better than those built for the same steam conditions 20 yr. ago. Most of the improvement is in the turbine as generator losses were always small, only about 4 out of the 17 per cent being due to improvement in generators.

One industrial plant recently took advantage of the relatively large increase in turbine efficiency by buying a new turbine to drive an old generator. The steam conditions were unchanged, 150 lb., 0 deg. F., 28 in., yet an improvement ranging from 13.5 to 22.5 per cent was obtained. The guarantees for both machines are shown in Fig. 1. The improvement in water rate is only a part of the story for the new unit is built so that it can be readily altered for steam conditions up to 450-lb. gage, 750 deg. F. total temperature to obtain the increased cyclic efficiency just described. In addition, extraction openings are provided so that the benefits of feedwater heating can be obtained and it would not be unfair to assume that the efficiency of the original turbine had decreased a good deal during its 19 yr. of service. Taking everything into consideration, the customer will probably save enough fuel in less than 2 yr. time to pay the total cost of the new installation and will be in a position to repeat by installing new high-pressure boilers.

So much has been written in technical publications during the last few years concerning regenerative feedwater heating that it only seems necessary to state the improvement resulting. In a 500-kw. unit with feed water being heated to 220 or 260 deg. F., 4.5 per cent is a conservative figure, while in a 10,000-kw. unit 9 to 10 per cent is commercially attainable as shown in Fig. 2. The lower rating would utilize single-stage bleeding and the larger four stages. Practically all condensing turbines built today are arranged for feedwater heating to the highest temperatures commercially practicable.

POWER PLANT ENGINEERING September 1933

Utilities Submit Light and Power Code

WORKING COOPERATIVELY with the American Gas Association the Edison Electric Institute has prepared a code for the electric light and power industry which has been submitted to N. R. A. Administrator Hugh S. Johnson. The code, it was announced by Floyd Carlisle, chairman of the code committee of the Institute, would add 50,000 employees to the 350,000 persons now employed by the power and gas industries in the United States.

The code provides a maximum 40 hr. week for minimum wages. At present the 48 hr. week is generally observed in the industry because of the 24 hr. daily service required of the utilities.

At this writing the submission of this code has caused some dissent in the Institute membership and two companies, the Hartford Electric Light Company, and the Consolidated Gas, Electric Light and Power Company of Baltimore, have indicated their inability to sign it, and have offered their resignations from the Edison Electric Institute.

This refusal to abide by the code is due not to the inability of the companies to meet employment conditions, but the question of how public service corporations subject to regulation by state authorities can properly agree to function under the code. Into the tangle is involved the political fears and ambitions of members of state regulatory commissions.

Both of the companies that have tendered their resignations, are developing codes and plan to go along with the national recovery administration.

The light and power code, as submitted and with several modifications since its first draft, is as follows:

PURPOSE—The declared purpose of this code is to effectuate the policy of Title I of the National Industrial Recovery Act during the period of emergency as to all persons, firms, associations or corporations producing, transmitting, distributing and (or) selling electricity.

DEFINITION—The Edison Electric Institute affirms that it imposes no inequitable restrictions on its membership and participation in its activities, and it is truly representative as a national association of the electric light and power industry of the United States.

I. Labor Provisions—As required by Section 7 (a) of Title I of the National Industrial Recovery Act, the following provisions are conditions of this code:

1. Employees shall have the right to organize and bargain collectively through representatives of their own choosing, and shall be free from the interference, restraint or coercion of employers of labor, or their agents, in the designation of such representatives or in self-organization or in other concerted activities for the purpose of collective bargaining or other mutual aid or protection.

2. No employee and no one seeking employment shall be required as a condition of employment to join any company union or to refrain from joining, organizing or assisting a labor organization of his own choosing; and

3. Employers shall comply with the maximum hours of labor, minimum rates of pay and other conditions of employment, approved or prescribed by the President.

II. CHILD LABOR—After August 31, 1933, no person under sixteen years of age shall be employed, except that persons between fourteen and sixteen years of age may be employed for not to exceed three hours a day and those hours between 7 a.m. and 7 p.m., in such work as will not interfere with hours of day school.

III. HOURS OF EMPLOYMENT AND WAGES—The following paragraphs in this section III are in substitution for paragraphs 2 to 7, inclusive, of the President's reemployment agreement:

(A) No employee shall work for more than an average of 40 hours per week during any six weeks period, except those specified in Paragraph (B).

(B) Load dispatchers, emergency maintenance and repair employees, station and substation operators, their attendants, crews and helpers, if highly trained and not readily replaceable, whose duties must be continuously performed in order to render the public a safe and continuous service, may be employed not in excess of 48 hr. per week, so long as other competent employees are not readily available for such work, and in emergencies such employees may work more than 48 hr. per week, but in no case shall the hours worked exceed an average of 48 hr. for six consecutive weeks. All employers subject to this code shall proceed with the training of additional employees as rapidly as is consistent with the rendition of safe and continuous service, so that by March 1, 1934, as many employees as possible may be re-classified under the 40 hr. per week limitation; and report shall be made on said date of the extent of such re-classification to the National Recovery Administration.

(C) The maximum hours fixed in the foregoing paragraphs shall not apply where not more than two persons are employed in communities of less than 2,500 population, which communities are not part of a larger trade area; nor to employees engaged on emergency work; nor to outside salesmen; nor to employees in a managerial, executive, administrative or supervisory capacity, who now receive more than $35.00 a week. Population for the purposes of this agreement shall be determined by reference to the 1930 Federal Census.

(D) Employees shall be paid at the rate of:

(1) Not less than $15 a week in any city of over 500,000 population or in the immediate trade area of such city;

(2) Not less than $14.50 a week in any city between 250,000 and 500,000 population or in the immediate trade area of such city;

(3) Not less than $14 a week in any city between 2,500 and 250,000 population or in the immediate trade area of such city, and

(4) In towns of less than 2,500 population all wages shall be increased by not less than 20 per cent, provided that this shall not require wages in excess of $12 a week.

(5) This paragraph shall apply to all employees, except those covered by the provisions of the following paragraph (E).

(E) Employees of the classes who, on July 1, 1933, were paid on a hourly rate shall be paid not less than 40c per hour, unless the hourly rate for the same class of work on July 15, 1929, was less than 40c per hour, in which latter case the rate of pay shall not be less than the July 15, 1929, hourly rate of pay and, in any event, shall not be less than 30c per hour; PROVIDED that learners may be paid not less than 80 per cent of the minimum wage rate provided in the above schedule, but the total number of learners shall not exceed 5 per cent of the total number of employees employed by any employer subject to this Code.

IV. APPLICATION—If any employer in the light and power industry is also an employer in any other industry, the provisions of this agreement shall apply to and affect only that portion of his business which is included in this industry.

V. ADMINISTRATION—The Edison Electric Institute is hereby designated the agency for administering, supervising and promoting the performance of the provisions of this code by the members of the light and power industry. The Edison Electric Institute shall appoint a recovery executive committee to exercise such functions on behalf of the Edison Electric Institute, and the facilities and departments of the Edison Electric Institute shall be available to make the administration effective and efficient.

In order to keep the President of the United States and the administrator informed as to the observance or non-observance of this code, each employer shall prepare and file with the statistical department of the Edison Electric Institute at such times and in such manner as may be prescribed, statistics covering the number of persons employed, wage rates, earnings, hours of work and such other data or information as the recovery executive committee may from time to time require.

Any employer in the light and power industry may participate in this code and in any revisions or additions thereto by signifying his intention and agreeing to pay to the Edison Electric Institute the proper pro rata share of the cost of creating and administering this code.

VI. AMENDMENTS—Such of the provisions of this code as are not required to be included therein by the National Industrial Recovery Act may, with the approval of the President, be modified or eliminated as changes and circumstances or experience may indicate.

Steam Jet Refrigeration and Air Conditioning

DATA FROM REPRESENTATIVE INSTALLATIONS SHOW WHAT CAN BE EXPECTED.* BY R. M. McQUITTY AND R. M. MULLEN

CONTINUED GROWTH of air conditioning during the last two years has actually developed a specialized field of engineering and special equipment is constantly being brought out to meet the new demands. Some of the important features of this equipment are: It must be automatic; first cost and operating cost must be low; it must operate efficiently on widely varying loads; it must be compact; safety must be assured; equipment must be simple to operate. It was only natural that the reconsideration of water as a refrigerant would result when refrigerant temperatures above 32 deg. F. became practical and when the demand for simplicity and safety became more apparent.

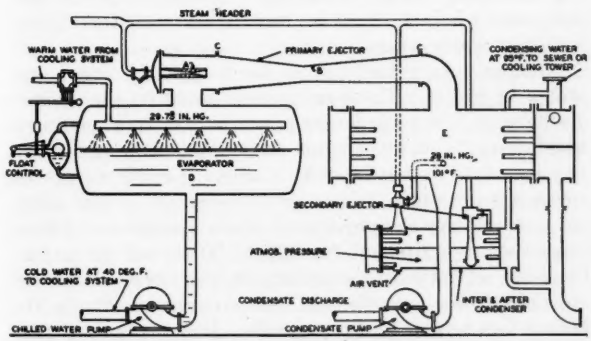


FIG. 1. SCHEMATIC DIAGRAM OF STEAM JET REFIGERATION UNIT

In vacuum refrigeration water is cooled to low temperatures by evaporating or vaporizing a small portion of the water at low absolute pressure, or in other words, under a high vacuum. Steam jets, sometimes called thermal compressors, are usually employed to create a vacuum. Water can be cooled nearly to the freezing point in this way, but equipment has much greater capacity at higher temperatures.

Since water, as commonly used as a circulating medium for air conditioning, usually ranges from 40 to 55 deg. F. the evaporation method is from that point of view a quite suitable one. Its efficiency is not as high as that of the positive compressor type, but when low-price steam is available, it is frequently the more economical system for air-conditioning purposes. One factor that must not be overlooked in determining the economics of the steam-jet type of refrigerating system is the cost of cooling water or of operating cooling towers as the amount of water required is from two to four times that needed for mechanical refrigeration.

A few manufacturers are building this equipment for small installations and several of the larger power plant equipment manufacturers are prepared to furnish such equipment in sizes from 25 to 1000 t. capacity or larger. The first cost is relatively low, especially in the larger sizes. The space required is small and the maintenance and operating labor quite low. The refrigerant, water, is harmless.

*Taken from a paper presented before the N.D.H.A.

OPERATION

Refrigerant water is sprayed into a flash tank D, Fig. 1, in which a high vacuum is maintained by means of a steam ejector A. At an absolute pressure of 29.75 in. of mercury the water in the flash tank will boil or vaporize at all temperatures above 40 F. For each pound of water thus evaporated approximately 1000 B.t.u. must be absorbed for heat of vaporization. This heat is taken from the remaining water in the tank thus lowering its temperature until a temperature corresponding to the vaporizing temperature at 29.75 in. of mercury is reached. The water thus cooled is circulated through an air washer or through cooling coils for the cooling process.

The primary ejector A is in reality a compressor in that the vapor from the flash tank is compressed to a slightly higher absolute pressure of approximately 28 in.

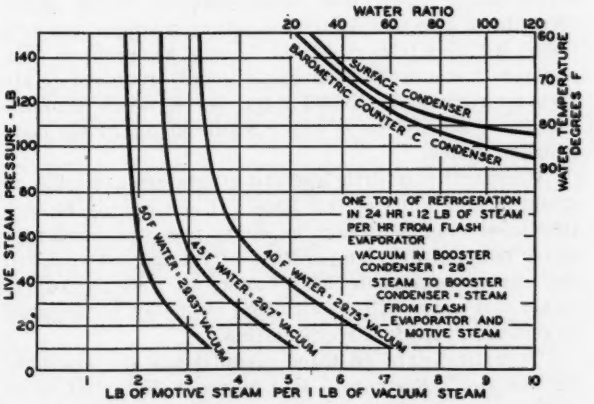

WATER RATIO
20 40 60 80 100 120
BAROMETRIC
SURFACE CONDENSER
COUNTER C. CONDENSER
LIVE STEAM PRESSURE - LB
140 120 100 80 60 40 20 0
WATER TEMPERATURE DEGREES F
60 70 80 90
ONE TON OF REFRIGERATION IN 24 HR = 12 LB OF STEAM PER HR FROM FLASH EVAPORATOR
VACUUM IN BOOSTER CONDENSER = 28"
STEAM TO BOOSTER CONDENSER = STEAM FROM FLASH EVAPORATOR AND MOTIVE STEAM
50 F WATER = 28.637" VACUUM
45 F WATER = 29" VACUUM
40 F WATER = 29.75" VACUUM
1 2 3 4 5 6 7 8 9 10
LB OF MOTIVE STEAM PER 1 LB OF VACUUM STEAM

FIG. 2. STEAM AND WATER DATA FOR STEAM JET REFRIGERATION UNITS

in the condenser E. As in the case of any other compressor it is necessary that the ratio of compression be as low as possible. In order that a vacuum of 28 in. be maintained in the condenser, the condenser cooling water cannot be heated above 101 deg. F. as this is the temperature at which steam condenses at 28 in. vacuum. Thus with comparatively warm condensing water of 85 deg. F. each gallon of water can absorb (101-85) $\times$ 8.33 = 133.28 B.t.u.

COMPARATIVE COST OF STEAM JET AND FREON REFRIGERATION UNITS

ASSUMED OPERATING CONDITIONS AND COSTS

			Ejector	Compressor
Operation per year ..... 800 hr.	Water ..... $0.095 per M gal.	Energy required	35 lb.per t.per hr.	1.194 kw-hr. per t.
Annual load factor 55%	Electricity.. 2 ct. per kw-hr.	Water required	6 g.p.m. per t. (cooling tower assume 5% loss)	2 g.p.m. per t. (no cooling tower)
Condenser water, av..... 85 deg.F.	Steam ..... $1.00 per M lb.			
Chilled water ..... 50 deg.F.	Fixed charges .... 12% of cost			
Steam ..... 125 lb. ga.				

ORIGINAL AND OPERATING COSTS (No air washers, fans or duct work included)

	100 T.		50 T.		25 T.	
	Steam Ejector	Freon Compression	Steam Ejector	Freon Compression	Steam Ejector	Freon Compression
Investment						
Refrigerating unit installed	$5,000.00	$14,500.00	$3,200.00	$9,500.00	$2,500.00	$6,500.00
Cooling tower installed	2,660.00	.....	1,490.00	.....	1,250.00	.....
Pumps and piping	500.00	.....	400.00	.....	.....	.....
Total investment	$8,160.00	$14,500.00	$5,090.00	$9,500.00	$3,750.00	$6,500.00
Operation						
Power	$321.64	$1,050.72	$160.82	$525.36	$80.41	$262.68
Water	75.84	501.60	37.62	250.80	18.81	125.40
Refrigerant Replacement	.....	125.00	.....	70.00	.....	50.00
Maintenance	75.00	50.00	60.00	50.00	50.00	40.00
Lubricant	1.00	5.00	1.00	5.00	.....	.....
Steam	1,540.00	.....	770.00	.....	385.00	.....
Total Operating	$2,013.84	$1,732.32	$1,029.50	$901.16	$534.22	$478.08
Fixed charges	979.20	1,740.00	610.80	1,140.00	450.00	780.00
Total cost	$2,993.04	$3,472.32	$1,640.30	$2,041.16	$984.22	$1,258.08

Assuming that the unit requires 35 lb. of motive steam per hour per 12 lb. of vapor extracted, the water requirements of a steam ejector would be [(35 × 1000) + 12,000 ÷ 133.28 or 352.64 g.p.h. or 5.877 g.p.m. per ton of refrigeration. The fact that this system can operate on 85 deg. F. cooling water is significant in that it makes it practical for use in the warmer climates. Considerable air and insoluble gases find their way into the condenser and must be removed. This is accomplished by means of the secondary ejectors and the two stage condenser F which discharge to the atmosphere.

Cooling Water

In the majority of cases it is necessary that the ejector system be operated in connection with a cooling tower. The water requirements are necessarily high as the condenser water must absorb approximately 12,000 B.t.u. refrigerating effect plus approximately 35,000 B.t.u. from the motive steam for each ton of refrigeration produced, giving a total of 47,000 B.t.u. to be absorbed. The water to a compression machine is only required to absorb approximately 15,000 B.t.u. per t. which accounts for the relatively lower water requirements of the compression system.

Comparatively little operating data are available on steam ejector units at this time. It can readily be seen that local conditions such as steam pressure, condenser water temperature, temperature of refrigerant required and service-seasonable load factor, as well as cost of steam and water will require that each unit be designed to suit the individual requirements.

Operating data on three installations are available. In Maurice's Restaurant in Chicago a 27-t. unit is installed to cool 26,000 cu. ft. by means of unit coolers. About 8,000 c.f.m. of air is circulated about 5 hr. per day. At full load about 780 g.p.m. of condenser water and 950 lb. per hr. of 100 lb. ga. steam is used. The approximate steam requirements being: June 71,000; July 149,000; August 180,000 and September 133,000 lb.

At Kips Bay a 25-t. experimental unit was tested for 15 min. at 31.6 t. capacity. With condenser water 74-91 deg. F. and refrigerant water 60-45 deg. F., the unit used 1,064 lb. per hr. of 102 lb. ga. steam which is 33.7 of motive steam per ton of refrigeration. At Snyder's Restaurant in Detroit a 14-t. unit using 31 lb. ga. steam and cooling 26,000 cu. ft. through cooling coils with 31 per cent recirculation was tested for 15 hr. with the average load for 10 hr. continuous operation 13.79 t. Temperatures were condenser water, 72-97 deg. F.; refrigerated water, 51.7-47.2 deg. F.; average outside, 78.5 deg. F.; average inside, 75.8 deg.; maximum outside, 84.4 deg. F.; maximum inside, 79.2 deg. F. During this time the unit used 4,747 lb. of steam and 22.7 kw-hr. for the refrigerant water pump.

General characteristics as to steam and water are shown in Fig. 2. These curves are based on the ejector discharging into a condenser pressure of 2 in. of mercury absolute or 28 in. of vacuum. Based on steam and water requirements as outlined by various manufacturers of steam ejector units, these curves represent a fair average. A relative comparison of steam ejector and Freon compression equipment for 100 t., 50 t., and 25 t. jobs has been set forth in the accompanying table. Premises on which these hypothetical comparisons are made are believed to be fair and reasonable. It is recognized that many variations may occur in specific installations, however, that may materially alter the conditions as set forth and accordingly change the comparative results or figures.

Although the operating costs are slightly higher for the steam equipment for the basis assumed, the investment costs and consequently the fixed charges are materially lower for the steam equipment, producing a favorable total cost for steam as compared with electric equipment for all three assumed capacity sizes. By-product uses or applications in specific cases may further materially affect these comparative figures.

Experiments in Germany with hydrogen as a fuel for internal combustion engines indicate that it can be used successfully in any gasoline engine with usual compression pressures, by adding a special hydrogen valve and valve gear. Higher compression increases output, a tentative ratio of 8 to 1 being suggested as a standard. No self ignition was experienced at any pressure. Possible use is in countries where all fuel has to be imported but excess water power is available. Water can be separated by electrolyzers into hydrogen and oxygen, which can be transported by pipe lines or in flasks and used to run combustion engines at any desired point.

Diesel Engine Lubrication

CYLINDER OIL SUBJECTED TO FLAME TEMPERATURE SEES HARD SERVICE BUT IT IS QUESTIONABLE IF IT BURNS.

By A. N. KENWORTHY*

RECENTLY a successful engineer defined lubrication costs as, "the cost of the oil plus the cost of what the oil was supposed to, but failed to do." In a normal installation, say a Diesel of from 150 to 175 kw., the average cost per kilowatt-hour delivered at the switchboard should run between 1.05 and 1.10 ct. What percentage of this production cost can be charged against lubrication has never been accurately calculated as there are so many variables, such as mechanical condition of the engine, fuel used and combustion, which enter into the calculation, that true figures are exceedingly difficult to ascertain.

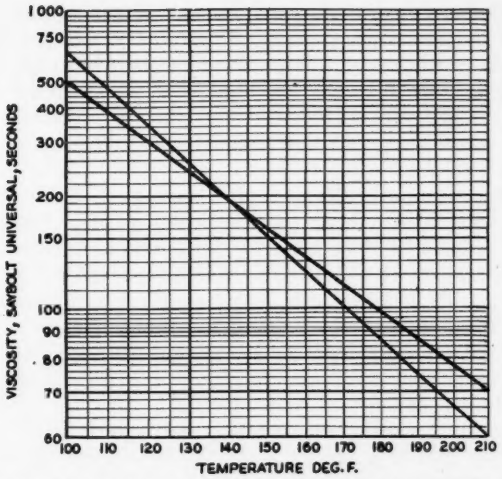
Functions of a high-grade lubricating oil in a Diesel engine cylinder are as follows: It must form and maintain a complete oil film between the moving parts at all times, replacing metallic friction with a minimum of fluid friction; it must form and maintain a durable piston seal, thereby eliminating blow-by; it must be of such quality that it can be fed in exceedingly small quantities and at the same time comply with the above two items; it must be chemically and physically stable and must resist the destructive action of the heat encountered during the explosion and exhaust strokes; it must not deteriorate and form carbonaceous deposits.

During the firing stroke, the oil is subjected to enormously high temperatures, and some operators and lubricating experts contend that the oil film actually burns away as the piston recedes from the heads of the cylinder. We do not agree with that theory. Admittedly the oil film is on one side exposed to a temperature in excess of 2300 deg. F. and to an open flame; but the other side of the oil film is in intimate contact with the cylinder wall around which there is a steady flow of cooling water with an average inlet temperature of between 50 and 70 deg. F.

BURNING VS. NON-BURNING THEORY

That these high temperatures and the open flame have a destructive effect on the strata of the oil film exposed to them cannot be denied. Of course, the flash point of the oil has a large bearing on the question, and the exponents of the "burning film" theory use the flash point as partial proof of their theory. These same people lose sight of the fact that flash points, as written into the various specifications, are measured at normal pressures. They overlook the fact that the pressure in the Diesel combustion space is about 1000 lb. per sq. in. and that the flash point of the oil under these conditions is much higher.

The fact that the oil is delivered to the cylinder walls while it is still cool points to the correctness of the "non-burning" theory. This oil film, renewed with cool oil from one to four times per second, depending on the speed of the unit, must be heated up to its increased flash point before it will burn, and this in spite of the fact that it is in contact with a relatively cool cylinder wall. A substantiation of the "non-burning" theory can be obtained by spreading a thin film of oil on a tin plate. Hold the plate over a Bunsen burner, with the oil directly in contact with the flame, and see how long it takes to set the oil on fire.



THE HIGH VISCOSITY OIL AT 100 DEG. F. MAY BE THE LOW VISCOSITY OIL AT 200 DEG. F.

DEMANDS ARE AT VARIANCE

A great deal of the formation of carbonaceous deposits is attributable either to the grade of fuel oil used or to incomplete combustion. It is essential, therefore, that high-grade lubricants be chosen. Many people contend that highly viscous oils are absolutely necessary for the lubrication of Diesel engine cylinders. These same people insist on an oil with minimum carbon-forming tendencies, entirely overlooking the fact that, in general, the more viscous the oil, the more pronounced are its carbon-forming tendencies.

Viscosity of the lubricant has an important relation to the film strength and the resistance to rupture of the piston seal. Viscosity, however, does not in any way represent the lubricating efficiency of the oil as the rate of change of the viscosity as the temperature of the oil increases is even more important, for it is the resistance to change under heat that distinguishes the quality Diesel engine oil from the inferior one.

Consider for a moment a Diesel oil specification calling for an oil of from 500 to 600 sec. Saybolt viscosity at 100 deg. F. Suppose two oils, one of 500 and the other of 600 sec., were submitted. The man who held viscosity of paramount importance would choose the heavier (600 sec.) oil. If this oil were an ordinary lubricant, its resistance to change when subjected to heat would be low with the result that at operating temperature it might have much less viscosity than the 500 sec. viscosity oil. If the 500 sec. viscosity oil were a quality oil built especially for Diesel work, its heat-resisting qualities would be high. Thus, we see that the viscosity of the oil at 100 deg. F. is not a true guide, for both oils meet the specification. The viscosity of the oil at working temperatures is what counts.

Diesel engine oil must be absolutely neutral, inas-

*Engineer, E. F. Houghton & Co., Philadelphia, Pa.

much as acidity would result in serious etching and pitting of the working surfaces. Ordinary oils are produced in wholesale fashion; they must be, in order that they may be marketed at low prices. Low-priced oils are, in general, acid-washed and then neutralized. In this wholesale production complete neutralization is seldom attained.

Lubrication of Diesel engine bearings is also a problem which demands an oil of high lubricating value and one which will stand up under extended use and severe punishment. It will be seen, therefore, that oils for the lubrication of Diesel engines must: Have minimum carbon-forming tendencies; resist the thinning-down effect at high temperatures; have high film strength, and at the same time maintain the film while presenting the minimum amount of fluid friction; separate readily from dirt, carbonaceous matter, and water; be of such quality that only small quantities are required to maintain efficient lubrication.

Only quality oils can live up to the rigid requirements outlined above and it is from this source alone that true lubricating efficiency can be obtained.

Sand Blast for Cleaning Metal Surfaces

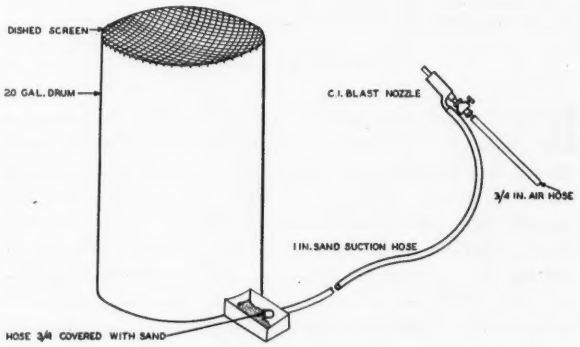
By A. S. Jamieson

PRESERVATIVE coatings to prevent the corrosive action of hot or cold water will do little good unless applied to the bare, clean metal, which means that scale, rust, grease and dirt of all kinds must be removed. Tanks, pipe, boilers and in fact all iron work have a coating of scale when received for erection, unless ordered scale free. If the new material is to be treated with a preservative, the scale must be removed. A quick, positive way to clean metal is by means of the sand blast, which will penetrate corners, seams, cracks and pockets that cannot be reached in any other way.

For use about the plant a portable sand blast is easily and cheaply made and can be used anywhere that compressed air is available at 70 or 80 lb. pressure. The blast nozzle will raise the sand to quite a height and will do effective work in any position. The commercial sand blast nozzle shown is really a well proportioned air ejector.

While an ejector may be made of pipe fittings, it will last but a short time if used for a sand blast nozzle. The regular sand blast nozzle is all cast iron, with ejector and discharge tubes easily renewable. Air comes through ordinary ¾-in. air hose, the suction hose for the sand being 1-in. air-tool hose, any length up to 20 ft. All connections on the air hose should be made with the regular air hose fittings to keep them from coming off.

For the sand the receptacle may be any metal drum but should have a capacity of at least 20 gal. The top head should be removed and a fine screen provided to keep trash and coarse particles from entering with the sand. For feeding the sand to the suction hose a small hole 1 to 1¼ in. diam. is cut close to the bottom of the drum, a small box open on the top, 4 in. wide, 3 in. deep and about 6 in. long riveted or welded to the drum in front of the hole, with a hole to fit the suction hose cut in the box near the bottom, on one side and as near the front as possible. The suction hose is placed so that about three-quarters of the opening in its end is covered with sand at all times. When the best position for feeding the sand is found a weight is placed on the hose to hold it in place. The hose is only partly covered because



THE BLAST NOZZLE IS OF CAST IRON WITH AIR AND SAND HOSE CONNECTIONS AS SHOWN. SOME AIR IS ADMITTED WITH THE SAND FROM THE BOX AT THE BOTTOM OF THE DRUM

the ejector nozzle will not pull unless some air is allowed to enter the suction hose along with the sand.

Besides the sand blast nozzle, hose and drum, a good sand blast hood with compressed air inlet is absolutely necessary, also respirator and soft leather gauntlet gloves. The respirator should be worn with the sand blast hood when sand blasting in confined spaces such as drums, tanks and heaters, as it will be found that sand and dust will find their way into the mask, regardless of the air feed into the hood. Sand forced from the nozzle at high velocity will cut anything with which it comes in contact, hence the operator must be well protected. All bearings and bright surfaces in the vicinity should be well covered before starting sand blasting.

Fine, sharp, well-dried sand is suitable for cleaning badly corroded boiler plate and cast iron. Boiler plate that is badly pitted and corroded can be thoroughly cleaned at the rate of 10 sq. ft. an hour. Cast iron surfaces require longer time. After reusing the sand two or three times, it will be reduced to a powder so as to be of little value for cleaning and should be disposed of.

Surfaces to be sand blasted should be dry as possible so that the sand will fly off and can be reused once. Sand blast has been used in our plant for cleaning coal and ash-handling equipment, the inside of return tanks, open heaters, pump casings, brick and concrete surfaces before painting or repairing, and the outside surfaces of iron work before painting.

Sand blasting of the inside surfaces of cast-iron vessels is a slower and harder job. Such surfaces that have been exposed to hot water under slight pressure for 5 or 6 yr. may be coated, not only with rust blisters, which are easily removed by sand blasting, but upon close examination a coating of oxide will be found varying in thickness and having all the appearance of clean cast iron. On removal of this coating by chipping and sand blasting will be found a badly pitted surface. After thorough cleaning, this surface should be treated with preservative to stop further corrosion.

Readers' Conference

Temperature Control Equipment Installed Inexpensively

FIGURE 1 SHOWS the heating system of an office building which purchases steam from a central station at a cost of $1.00 per 1000 lb. of steam. The radiators installed have 67,000 sq. ft. of radiation. Tenants started to move in in May, 1931, and during the heating season of 1931-32 it was 50 per cent occupied. We used 16,000,000 lb. of steam for the season, extra steam being used to dry out partition walls as space was divided to suit tenants.

During the season of 1932-33 the building was 75

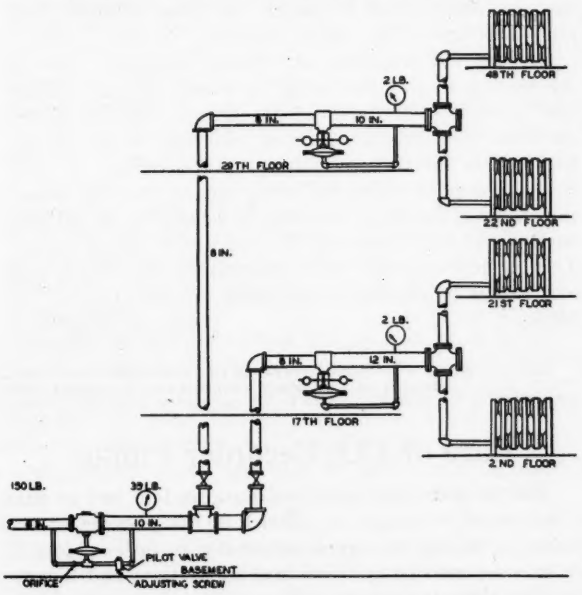


FIG. 1. STEAM FLOW THROUGH SYSTEM CONTROLLED BY PILOT VALVE

per cent occupied. We used 15,000,000 lb. of steam or 69 lb. per degree day per 1000 cu. ft. of space. This was controlled manually by varying the pressure in the system with the pilot valve of the primary reducing valve in the basement.

Pressure was carried from negative pressure for warm days to 35 lb. for cold days and the vacuum in the return lines varied to suit the pressure. Daily records showed the pounds of steam used per degree day per 1000 cu. ft. of space jumped 50 per cent on warm days and averaged 25 per cent, over 6 lb. for the season. The owner was notified that it would pay him to orifice the system and install a temperature control. After several bids were submitted by different contractors, he decided the outlay was too great, the contractors being reluctant to take the job on the pay-as-we-save basis. It will be seen from Fig. 1 that the primary reducing valve reduces the pressure from 150 to 35 lb. in the 10-in. main and from 35 lb. to 2 lb. at the secondary valves, two 8-in. lines being taken off in the basement, one going to the seventeenth floor and feeding up to the twenty-first floor, and then down to the second floor.

The other 8-in. line goes to the twenty-ninth floor and feeds all radiators from the twenty-second to the forty-eighth floor. This summer we installed the rigging shown in Fig. 2. A motor operates a crank through a train of gears and turns the crank 90 deg. and then stops; controlled by a thermometer. The thermometer was installed in the coldest office and set for 72 deg. to close and 69 deg. to open.

When the room temperature reaches 72 deg. the thermometer makes contact and puts current on the motor which raises the crank to the up position closing the secondary reducing valve and shutting off the steam. When the temperature reaches 69 deg. the motor turns the crank to the down position and opens the reducing valve. The lever of the reducing valve is connected to the crank of the motor with a light chain, so that if the pressure in the low pressure side should go above 2 lb. without the temperature being up to 72 deg. the reducing valve is free to move to the closed position and control the pressure in the low pressure side.

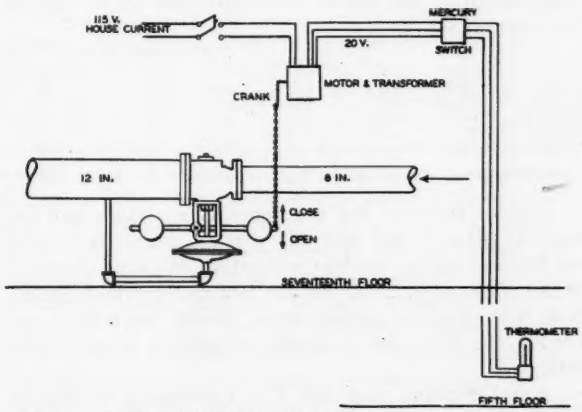


FIG. 2. REDUCING VALVE OPERATED BY MOTOR AND THERMOMETER

We had to buy two outfits, one for the seventeenth and one for the twenty-ninth floor valves. The house crew did the wiring and the complete job cost less than $80. We expect to save at least 2,000,000 lb. of steam that would be wasted in overheating. Extra thermometers can be added at any time and connected in series if they are required.

Nutley, N. J. THOMAS SHEEHAN.

Surplus Power

UNFORTUNATELY, I cannot agree with Alfred W. Fox's analysis of surplus power possibilities which appeared on page 312 of the July issue. He makes a study of the problem of a generating station with a maximum load of 89,000 kw. and purposes to chop 20,000 kw. from the peak, this to be taken care of with firm surplus power from isolated plants.

In the first place I question his estimate of $85 per

kw. for the generating station capitalization and $50 for that of the isolated plant surplus power equipment. If the 20,000 kw. load could be carried by one industrial plant, $50 per kw. would be about right, but in the practical solution of this problem the load will have to be shared by a large number of small plants and $50 per kw. is not adequate.

In the city of Chicago there are only 50 isolated plants with total capacities of over 2000 b.hp. each and probably not ten of these have a potential surplus power capacity of this amount. If surplus power deserves the attention of the engineering profession it must be broad in its adaptabilities and industrial power plants with at least 1000 b.hp. surplus capacity should be able to join in.

Mr. Fox assumes 70 lb. as the water rate of the surplus power machine, and on this basis the total steam required will be 1,400,000 lb. per hr., or 47,000 b.hp. at normal rating, or 23,000 b.hp. at 200 per cent rating. The load must be shared by at least ten plants, provided there are that many in the vicinity which can average 2300 b.hp. each in excess of the steam requirements for their own power.

As to the magnitude of the capital investment, authorities disagree, but, using figures given in Mark's Handbook, 1928 edition, page 1176, with correction for present conditions by adding 50 per cent, gives the amounts shown below. At any rate what we are after is not absolute quantities, but the ratio between one set of figures and another set.

	Capacity of Plant, kw.	
	4000	30,000
Boiler room equipment	....	22
Generating equipment	33	23
Electrical control equipment	7	6
Service equipment	8	6
Engineering service	14	8
Total additional capitalization, dollars per kw.	62	65

Capital required for the generating station and industrial plant is $65 and $62 per kw. respectively and not $85 and $50 as Mr. Fox estimates. We are interested in the ratio which is 65/62 and not 85/50, which means that with surplus power, even though no boilers are needed, the reduction in capital investment is only 5 per cent.

Another point that Mr. Fox overlooked is that of labor. Generating stations have their maximum peak in the evening and if industrial concerns are to supply firm power they must stand-by until 10 p.m. Since industrial concerns do not ordinarily operate at night, this will necessitate extra personnel for the power plant. At least two men for each plant will be necessary and we can assume that at least five of these power plants do not have an evening shift, so that 10 extra men will be needed, at say, $1500 per man per year. Now we are in a position to compare costs.

	Gen. Station carries entire load.	Peak 20,000 by surplus power.
Fixed charges	196.000	186.000
Additional fuel	3.000	10.000*
Additional labor	3.000	15.000
Total additional annual expense	202.000	211.000

In the face of this, it is evident that surplus power in its broad application, with the exception of some special cases, is not a workable proposition. Even if we accept the estimate of Mr. Fox, which is about $50,000 in favor of surplus power even then the deal is not attractive as there are too many assumptive factors and no sane industrial plant owner will spend $1,000,000 when the prospects of gain are only 5 per cent with all its uncertainties.

Chicago, Ill. N. T. Pef.

*On the basis that half of the exhaust steam from the surplus power will be utilized in process and the other half lost to the atmosphere due to lack of synchronism between power and steam demand.

Maintenance of Feedwater Regulators

It may be possible that some readers of Power Plant Engineering have misconstrued my item under the above heading on page 315 of the July issue, assuming that this scaling is a common fault with expansion tube feedwater regulators and is a fault to be expected. Also they might have assumed in some cases that the scaling occurred only in the expansion tube and not in any other part of the feedwater system. This was not the case, as the scaling to which the item referred took place throughout the entire system.

Recent investigation has shown that the cause of the scaling in this particular case was due to a defective process steam coil which allowed the brine and chemical solution to leak back into the feedwater system. This solution probably together with the feedwater treatment which was being used at the time caused the chemical reaction resulting in scaling of all internal surfaces of the boiler and the feedwater piping system. This is just another case illustrating the widespread evil effects of improper feedwater treatment.

Milford, N. J. Harry M. Spring

Editor's Note: The manufacture of the expansion tube regulators have no record of any other tube becoming choked with scale despite the fact that some 40,000 have been shipped to users.

Care of CO_2 Recorder Piping

Piping for CO_2 recorders must be laid out so that a minimum resistance is offered to the passage of the gases; it should be lagged externally to prevent loss of heat and prevent any possible condensation, and it must be kept clean internally. All necessary bends should be of a large radius.

To clean the piping, the best way is to blow through it with compressed air at a pressure not exceeding 20 lb. per sq. in. A tap should be installed to shut off the instrument from the piping while cleaning, otherwise the air pressure might cause the diaphragm or vanes to buckle. Grit and other injurious foreign matter are prevented from entering the instrument by the use of filters. These filters clog and offer a high resistance to the gases and thus need to be cleaned occasionally. Compressed air at a pressure not exceeding 10 lb. per sq. in. will remove the collected dust. The frequency of cleaning will depend on the nature of the fuel used, the draft, and other peculiarities of the plant.

Another possible trouble is internal corrosion. The possibility of its occurrence and its seriousness depends in a large measure on the class of fuel used, sulphurous fuels being particularly guilty. Corrosion can be prevented by keeping the parts painted with liquefied lead paint. The fan chambers, impellers, etc., should be periodically inspected for signs of wear or corrosion.

Herts., England. W. E. Warner.

The Smoke Nuisance and Its Abatement

IN SPITE of the fact that cities everywhere legislate to a degree against the emission of dense smoke from stacks and by persuasion and education have endeavored to abate the smoke nuisance, little definite progress has yet been made toward a solution of the problem since the first use of coal about 37 A. D. Authorities charged with the duty of abating this civic nuisance must understand there is a distinct difference between, 1st: Reducing the volume of dense smoke and, 2nd: actually abating the nuisance attributable to the emission of any smoke, solids and gas. The oversight of the latter fact is the reason the problem remains unsolved.

It is the present practice of smoke inspectors, operating within the generally accepted terms of ordinances, to devote their entire efforts toward reducing the volume of visible black smoke and almost wholly ignoring the greatest source of air-pollution, that is, the emission of all smoke which, regardless of color, carries large quantities of solids, and gases and which is the greatest cause of annoyance and expense to the public.

While it is true improved methods of combustion have reduced, in some cities, the total amount of dense smoke emitted into the atmosphere, it is certainly a fact that the public is not satisfied with the results and are clamoring for a cessation of the dirt-fall which is responsible for the ruination of household goods and property damage to say nothing of the injuries to health. Better combustion usually increases the volume of fly-ash and cinder discharge.

Previous methods of solving this problem have failed dismally. Means have been perfected of late which offer a genuine solution, in fact absolute abatement is possible at a reasonable cost. The monetary loss on account of smoke runs into countless millions of dollars every year. This deplorable waste can now be terminated by the installation of a smoke washer, scrubber; or other entrapment equipment.

The color of the stack discharge (i. e., dense or light) has little to do with the amount of solids and gas emitted into the atmosphere. The public should demand a halt on this deposit of filth, to which the greatest amount of air-pollution can be charged.

The accomplishment of an unpolluted atmosphere can be secured by the adoption and enforcement of the following simple regulation governing the issuance of construction permits:

> HEREAFTER, the Smoke Inspector, or any other designated Official, shall issue a permit to install stationary fuel burning plants or for the reconstruction of existing stationary fuel burning plants of all descriptions, only when plans and specifications for such provide for the installation of equipment the purpose of which is to prevent, to the greatest practical degree, the discharge of solids and noxious gases into the atmosphere. Permission to operate such fuel burning plants shall be issued only after inspection has satisfied him that the plant is so equipped as to be operated to prevent to the greatest practical degree the discharge of solids and noxious gases into the atmosphere.

Such a procedure is the only practical plan to follow to accomplish improvement and cities should adopt it as a fixed policy for the future if they hope ever definitely to abate the smoke-nuisance. When authorities realize that from 2 to 5 per cent of the fuel fired leaves the stack in some form of solids together with noxious gases they will appreciate that the proposed method of abatement alone offers a solution of the problem.

If you want cleaner air, stop the smoke and dirt shower; pass the right kind of law, then enforce it with power.

Chicago, Ill. H. W. EVANS.

Knot Kink

WHEN LOOKING over the pages of the July number I noted the knot kink on page 315. Liquid glue is seldom available in a power plant, but liquid such as black japan as used on steam boiler fronts, steam and other iron pipes or thin liquid shellac, or other moisture and heat resistant paints or mixtures are. Any one of the named liquids will serve as well or better than glue if the knot after being dipped in the liquid and still wet, is used to stir up some fine sand or cement, perfectly dry, the holding or non-slipping power of the knot will be increased.

Toronto, Ont. JAMES E. NOBLE.

Motor Pulleys

THERE SEEMS to be a great variety of notions regarding what should, and what should not, be used for a motor pulley. Some "rule of thumb" ideas have caused lots of money to be spent and power wasted in an effort to live up to them.

I well remember seeing, at a certain large mill, some very complicated drives and, wondering why countershafts were being used at all, asked the superintendent why he did not use a single belt drive. He explained that he could not do this because it was impossible to do so without making the motor pulley larger in diameter than the rotor and this, he said, would not work. As a matter of fact I know of dozens of motor drives that are giving complete satisfaction where the pulley is not only larger than the rotor but is actually greater in diameter than the motor itself.

Using large pulleys at high speeds is not, however, as simple as it seems. They must be of rigid construction, an accurate fit on the shaft and, above all, they must be carefully balanced. If it is at all possible the balancing should be dynamic rather than static because a statically balanced pulley may be considerably out of dynamic balance and vibration is particularly destructive to motors.

Some engineers make a lot of fuss about the weight of a motor pulley and want it to be as light as possible, but I have not found it so important. In fact on a rapidly fluctuating load a heavy cast-iron pulley is often an advantage. Then a lot also depends upon the direction of the belt pull; if this is up then a heavy pulley is better than a light one since it helps to balance the lift on the rotor.

The question of getting too high a pulley speed is not likely to be encountered on any standard machine drive for the simple reason that the manufacturers of these machines never ask for belt speeds in excess of safe practice. Naturally the pulley must be a good one

and well constructed and it is advisable when ordering high speed pulleys to state the revolutions per minute they are to run at so one suitable to handle the centrifugal stresses will be provided.

For loads that have a strong fluctuation, such as punch presses and shears, for example, my experience has been that a nice, smooth turned cast-iron pulley gives the best results. When the load comes on, this pulley will easily allow the belt to slip momentarily and thus allow the machine flywheel to deliver most of the energy as it is designed to do. On the usual more constant torque drives, pulleys having a higher coefficient of friction, such as wood, paper, etc., will give smooth running drives with little loss.

Great care should be taken to see that the motor pulley is properly fitted to the shaft because if it gets loose it will generally ruin the shaft before the trouble is discovered.

Moline, Illinois. GEO. P. PEARCE.

Crystallization of Metals Is Not Caused by Vibration

APPARENTLY IT is the general opinion of many mechanics, as well as many engineers of standing, that the source of failures of metal parts when subjected to repeated stresses is due to crystallization.

Prior to the extensive research which has been done in late years in metallurgy, and more particularly in metallography, it was perhaps a more or less universal opinion that the normal structure of metals was fibrous, especially wrought iron. In fact, for this reason, wrought iron was at one time considered superior to steel for construction purposes. It was also the consensus of opinion that repeated stresses, vibrations, or fatigue, changed the metal structure from fibrous to crystalline, thereby causing embrittlement and consequent fracture, along planes between the crystals.

This opinion is still entirely too widespread, for it is now known that all metals are crystalline, never fibrous. Substances passing from the liquid to the solid state become crystalline, i.e., the atoms or molecules of the substance so arrange themselves as to form small solids of regular geometrical outlines, such as cubes, octohedra, etc. Each of these spontaneously formed symmetrical solids is called a crystal and any substance made up of crystals is said to be crystalline.

Solid substances which are not crystalline are said to be amorphous (without form). They are characterized by the absence of any symmetrical grouping of their atoms or molecules. Pitch and glass are typical examples of amorphous substances.

It is further known that it is impossible to change the crystalline structure of a metal by subjecting it to repeated stresses or vibration. True recrystallization in steel can be accomplished only by the application of heat. When steel is heated or cooled through its critical range, its crystalline structure changes. The critical range for the eutectoid (0.85 per cent carbon steel) is from 1250 deg. F., to 1355 deg. F. At the latter temperature, known as the point of decalescence of the eutectoid, the carbon dissolves in the iron, accompanied by a corresponding change in the crystalline structure.

Under repeated stresses, in many cases millions of cycles, a metal part may suddenly fail with no warning and part of the fracture appear bright and crystalline. This no doubt led to the old theory of failure from crystallization. If, however, the planes of fracture of the broken part be carefully examined it will be seen that the outer portion of the fracture is dull and lusterless, while the remainder presents a bright, crystalline appearance. A minute examination of the lusterless part will show that the surfaces of fracture are very small, while the center portions will have comparatively large surfaces of fracture.

The larger surfaces of fracture noticed in the outer fibers of a fractured part have been slowly formed, having begun as small flaws from many centers, and continuing until continuous fracture has been accomplished throughout the extent of the extreme fibers. This of course greatly weakens the specimen and the stresses become so large that they suddenly tear the metal in two along the natural surfaces of cleavage of the crystal grains.

The center portion of the fracture in no way differs from the crystalline surface found in the bottom of the cup in an ordinary static tension fracture, except that the crystalline surfaces are somewhat larger. This is due to the fact that in the case of static tension fracture the metal has been elongated, so much so that the crystal grains have been reduced in cross-section, whereas in the case of fracture of the endurance specimens the material has not had time to elongate and the crystal grains retain their normal size. It is not the crystalline portion of the broken part which has failed by repeated stresses, contrary to the opinion of many, but the dull portion in the outer fibers. In the crystalline part of the fatigue fracture and in the crystalline part of the static tension fracture the failure is of the same nature. It is simply one of failure in cohesion.

Fatigue failures that are erroneously ascribed to crystallization are due to exceeding the stress the material will endure. At stresses near the endurance limit damage begins, finally resulting in the formation of small cracks within the crystals. These cracks grow large as the stresses are repeated and finally cause failure. It may take millions of cycles of stress to develop this damage so that it is apparent to the eye, or even the microscope, as a crack.

Poor fillets, sharp corners, tool marks, etc., tend to cause high local stresses and if these stresses are too high cracks will develop, and ultimately cause failure. But it should be carefully borne in mind that such failures are in no way connected with any change in the crystal structure of the parts involved.

Furthermore, the term "crystallization" should never be used in reference to the effects of repeated stresses, vibration, etc., but only in reference to actual changes in the crystalline structure, which is brought about by the application of heat as in the various processes of heat treating.

For more information on crystallization, or the absence of it under vibration, one should consult Letter Circular 204, of the Bureau of Standards.

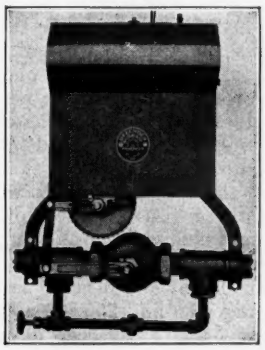
For very complete information on the subject of the crystalline structure of metals, the Metallography and Heat Treatment of Iron and Steel, by Albert Sauveur, will be found to be instructive.

Baltimore, Md. JOSEPH A. KENDRICK.

New Equipment

Defender Motor Operated Controls

FOR THE CONTROL of its new chronometer valves, the Defender Automatic Regulator, St. Louis, Mo., announces its Model B motor operated control for pressure regulation. These controls, applicable to vertical or horizontally installed valves, can be actuated by pressure, vacuum, temperature, volume, time or flow, the

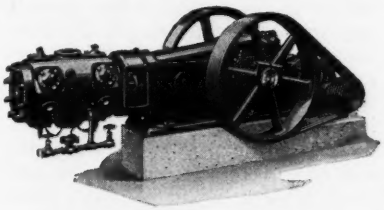


actuating medium for pressure service being a hollow coil spring adjustable from the outside for a pressure range of from 20 in. vacuum to 250 lb. ga. Regulators are mounted in a cast aluminum case 12½ in. square and 6 in. deep and weighing 25 lb. The case has a cast front cover and is furnished with a round form inlet switch with two fuses mounted on the inside. The illustration shows the control as installed on a horizontally installed valve.

New Compressor Announced by Ingersoll-Rand Co.

INGERSOLL-RAND CO., New York City, announces a new single-stage, belt-driven compressor, designated the Class ES, designed for heavy-duty service. It has one horizontal, double-acting cylinder and operates at moderate speeds. It is available in sizes from 10 to 125 hp., and for discharge pressures from 5 to 150 lb.

The machine is suitable wherever full-load, continuous service is required and wherever power cost is an important consideration, as friction is reduced to a minimum by a double row of Timken bearings on each end of the crankshaft. It will give economical standby service for large compressors whose full capacity is not always needed. It is well adapted for use in isolated plants where there is little supervision, for all applications where oil in the discharge line is objectionable, or for installations where a future change in pressure conditions



may call for a change in cylinder size. It will satisfactorily handle poisonous or inflammable gases, or any others that must be handled without leakage. Regulating equipment suitable for any conditions of service can be furnished.

Three New Types of Rubber-Insulated Cable

THREE NEW TYPES of rubber-insulated cable, insulated with heat-, corona- and moisture resisting compounds, have been announced by the General Electric Co.

Rubber insulation designated as Type GE-R359 is designed to operate at a maximum temperature not exceeding 75 deg. C. It is recommended for insulating cables for station, apparatus, transformer leads, motor leads, and power applications where a cable is required to be insulated with a compound which will stand much higher temperatures than the standard grade of rubber compounds previously available.

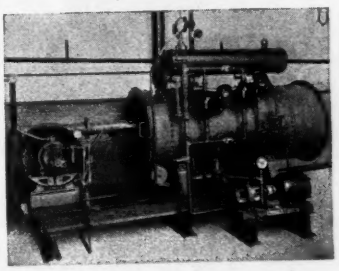
Type GE-R348 moisture-resisting compound is designed for use on cables which must operate in wet locations. It is particularly adapted for non-leaded submarine cables. This rubber compound is not corona-resisting, so that for higher voltages it is necessary to apply a shielding tape.

The third new compound, Type GE-R351, is a corona- and moisture-resisting compound which retains its original characteristics throughout its life. It is recommended on cable for high-voltage transmission, distribution, station, apparatus, parkway, tree wire, serial, submarine, and similar applications where a corona-resisting, high-tension, non-leaded or leaded cable is required. This type of compound is used to form the entire insulation over the conductor since it has both high dielectric and corona-resistant properties.

Cleaver-Brooks Oil Burning Boiler

CLEAVER-BROOKS CO., Milwaukee, Wis., has introduced several sizes of oil burning steam boilers designed to operate automatically at high efficiency, in a small space and at a low cost. The type of construction used eliminates the need and expense of a foundation.

By making the boiler and burner an integral unit and designing each for the express purpose of operating with the other, this company has been able to attain high overall operating efficiencies with its Oilbilt boiler.



All air delivered into the combustion chamber is handled by a blower, resulting in a controlled predetermined mixture of air and oil to insure perfect combustion and complete use of fuel. Operated with automatic controls, the burner runs intermittently to take care of fluctuating loads and makes only the amount of steam actually required. Sizes range from 5 to 500 b.hp. and in working pressures from vacuum to 200 lb.

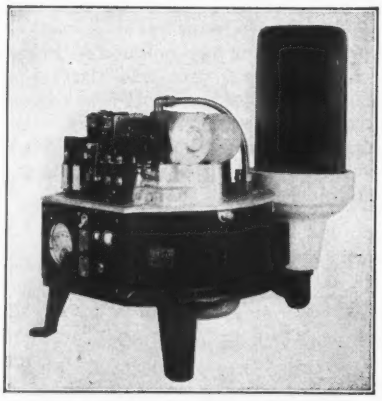
Starrett Vibrometer

THE L. S. STARRETT CO., Athol, Mass., has developed a compact, inexpensive instrument known as the Starrett Vibrometer for measuring the amplitude of vibration in machinery and power equipment. The instrument is particularly useful for checking the balance of units, revolving at high speeds, such as turbine rotors, by simple, comparative readings.

Elgin Hardimeter

THE NEW Elgin Hardimeter furnished by the Elgin Softener Corp., of Elgin, Ill., is an automatic instrument which, by means of the electric eye, tests the water produced by a zeolite water softener and sounds an alarm when the hardness exceeds any predetermined figure. The instrument is also used to check the brine wash water so that the softener will not be placed in service until all the brine has been removed.

This application of the electric eye is extremely simple. The instrument is connected to the soft water supply line by a small copper tubing and at predetermined intervals a sample of the water automatically passes into a glass cylinder.



A small quantity of chemical is mixed with the sample of water and if the water is zero hard no change occurs in either the color or turbidity of the sample. The slightest trace of hardness, however, causes both a turbidity and a change in color, such change being in proportion to the amount of hardness.

After time for reaction of the chemical with the sample, a beam of light is passed through the glass cylinder containing the test sample and strikes the photo-electric cell. By measuring the amount of electric current generated by the light sensitive cell, there is a definite measurement of the transparency of the sample with its chemical reagent which is inversely proportional to the hardness of the water.

Whenever the water hardness reaches the pre-determined hardness value for which the instrument is adjusted, an alarm is given by ringing a bell, the illumination of a light, or both. The alarm or signal is continuous until a reset key on the Hardimeter is operated.

The electric eye is a practical means for securing the full capacity of a softener without danger of over-running. Raw water from river or lakes varies in hardness and hence a water meter can never be set for the correct amount of water per regeneration.

When the instrument has indicated that the softener is exhausted, the operator proceeds to regenerate it and throws a switch key mounted on the instrument. Throwing this key causes the Hardimeter continually to sample and test the wash water, and changes the signal circuit so that no further alarm is given until a sample tests zero or salt free. The moment zero or salt free water is available, another continuous signal is given until the reset key is operated at which time the softener is again put into service.

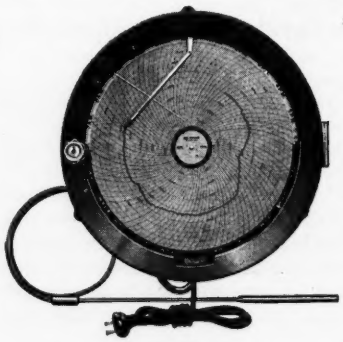
Two models of the Hardimeter are offered to test practically any kind of soft water supply. One model is designed for use where the water is practically uniform in color and turbidity.

In cases where water to be tested varies appreciably in either color or turbidity, an instrument is used with two glass cylinders and two photo-electric cells. Thus twin samples of the water to be tested are taken at the same moment, but the chemical reagent is mixed into only one of the samples. Light is then projected through each cylinder simultaneously, falling on separate photo-electric cells. The electric circuit is such that the output of the whole light sensitive system is proportional to the difference between the light absorption characteristics of the two samples and is independent of either color or turbidity present in the water being tested. This makes it possible to secure consistent and accurate results under the most widely varying color and turbidity to be found in practice.

Brown's New Recording Instruments

BROWN INSTRUMENT Co., Philadelphia, Pa., has just placed on the market an entirely new and improved line of 8-in. and 12-in. circular chart instruments. These instruments include thermometers in indicating and recording types for temperatures from —40 deg. F. up to 1200 deg. F., and indicating or recording pressure and vacuum gages for ranges from 10 in. of water up to 5000 lb. All types are offered in one, two or three pen models.

In developing this new thermometer line, much research was devoted to improving the helix mechanisms (Bourdon tubes). The mercury-filled helix is built of a special stainless steel which stands 100 per cent overload and provides



a surplus of power to move the pen. The gas and vapor type helices are made of heat treated phosphor bronze which gives greatly increased ruggedness and power. These thermometers may be located at distances up to 200 ft.

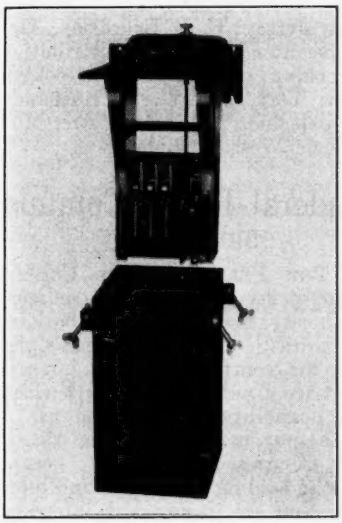
In the pressure and vacuum gages, three different types of actuating movements are employed. For ranges 10 in. of water to 30 lb., a flexible metal diaphragm is used. For ranges 30 and 200 lb., a spring-opposed bellows has been developed which gives a powerful pen action in this range. For pressures over 200 lb., a helix is used.

New Oil-Immersed, Explosion-Proof Switch

A NEW OIL-IMMERSED, combination switch, designated as CR7008, has been announced by the General Electric Company for use in Class I, Group D hazardous gas locations. The switch is available in three sizes for motors up to 50 hp. at 440-v. It is suitable for use in paint factories, lacquer plants, oil refineries, chemical houses, and in other places where it might be exposed to corrosive and explosive gases. Inasmuch as the device is of weather-proof construction, it may be located outdoors if necessary.

The combination switch consists essentially of three parts: a magnetic switch, a motor circuit switch, and a thermal overload relay which is reset by a plunger extending through the top cover. These parts, together with all connections, are located six inches below the surface of the oil in an oil-filled tank of welded construction. The tank, which is welded from heavy sheet steel, is supported from the top cover by four wing bolts. Handles on the sides of the tank facilitate its removal.

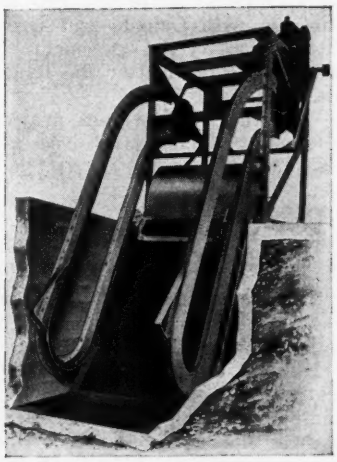
The magnetic switch used is of the same general construction as all General Electric magnetic switches. The motor circuit switch is a manual contactor with a sturdy snap-action, quick-make, quick-break mechanism. This kind of disconnecting device is particularly suitable for operation under oil. The operating handle of the motor circuit switch is interlocked with the tank so that the tank can not be removed unless the motor circuit switch is open.



The top cover of the tank is a heavy iron casting and is provided with three threaded conduit entrances for the line, motor, and control connections. The cover also has lugs so that the switch may be wall-mounted.

Self Cleaning Screen

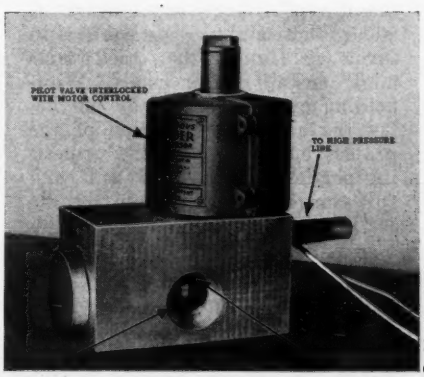
THE JEFFREY MANUFACTURING CO., Columbus, O., announces an improved self-cleaning bar screen, which is completely automatic in operation and is the result of a development over a period of 4 yr. Some of the advantages of this new screen are: A clear opening from side to side in the submerged portion with no cross members within the channel to act as obstructions; the special hinged scraper prevents jamming of the mechanism from the accumulation of foreign material in the bottom of the channel or upon the screen; the rake teeth pass entirely through the screen, cleaning not only the surface but also the spaces between the bars; before turning at the top of the screen to repeat its operation and after discharging its load, the scraper engages a wiper which removes material adhering to it; the control mechanism is such that the screen may be operated continuously or at intervals from two seconds to one hour; shear pins permit release of the mechanism without damage



should some unusual obstruction be encountered. The screen can be hand raked should an interruption of power occur.

Refrigerating Compressor Unloader

ELECTRIC MACHINERY MFG. CO., Minneapolis, Minn., announces the development of a new type automatic instantaneous unloader for small refrigeration compressors. This is an automatic pressure-differential-operated by-pass valve con-

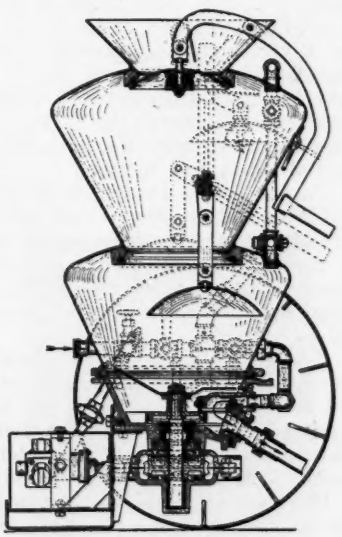


nected between the suction and discharge on the compressor and is controlled by a magnetic pilot valve which in turn is controlled by the frequency responsive relay on the motor starting panel. Automatic start and stop operation of the compressor units can be secured with use of the instantaneous unloader, the compressors starting and stopping by brine thermostats, suction pressure control or other means to maintain desired temperatures. Completely automatic operation provided by the automatic unloader permits the operator to work out of the compressor room which is a real advantage in many ice and refrigeration plants.

Gunitor Cementing Units

THE GUNITOR CO. has recently been formed with C. L. Dewey as president and general manager, W. McK. White, vice-president, and Sidney L. Dewey, secretary. Sales offices and factory are located in Elkhart, Ind., where a new extensive line of machines, known as Gunitors, are being manufactured.

Gunitors are designed for applying cement or refractory materials to surfaces to be repaired or restored by means of compressed air which shoots the material with great force onto the surface to be coated. They are also used for sand blasting. Ma-



terial is handled dry through a hose being conveyed to the nozzle by the current of air. At the nozzle it is mixed with water under the control of the operator. Material is placed in the charging chamber and mechanically fed into the air stream. With dual chambers continuous operation is maintained.

Motor driven and gasoline engine driven units on wheels are manufactured, also self-contained units with pug mixers to combine various materials.

Stoker For Mixed Fuel

FOR BURNING a mixture of coal and tan bark in the proportions of approximately 75 per cent and 25 per cent, a special stoker has been purchased by the Ashtabula Hide & Leather Co. from the Westinghouse Electric & Mfg. Co. This unit together with its boiler is part of a rehabilitation plan which the leather company is working on at the present time and is the second of its type purchased by that company.

These two units are providing satisfactory operation under the extremely hard service required when burning a mixture of coal and tan bark. The boilers were supplied by the Union Iron Works who have furnished this company with their boiler requirements for the past twenty years.

Federal Recovery Projects

FEDERAL PROJECTS approved by the President on July 28 involve the expenditure of about $210,000,000, which will be spread through the various parts of the country. The west will receive $63,000,000 in the Grand Coulee Project on the Columbia River and its branches and watershed. The effects of the construction of this project will cause direct expenditures in the States of Washington, Oregon, Montana, Idaho, California and Nevada.

Caspar-Alvoca Project is in the Mid-West and involves the expenditure of $22,700,000. This project is on the North Platte river and will cause direct expenditures in Wyoming, South Dakota, Nebraska, Kansas and Colorado.

Tennessee Valley project, more generally known as the Muscle Shoals will require $50,000,000 and will be expended in the valley of the Tennessee and affected rivers and watersheds. This will take place mainly in the state of Tennessee, but will also be spread among the states of Alabama and North Carolina.

Deepening the Mississippi-Missouri Rivers takes care of the work that has not been attempted heretofore. This will include that particularly in the upper reaches of the rivers, and is an attempt to save millions of dollars annually as well as many lives, that are usually lost in the floods that take place in these regions. It will also provide for navigation up to 9 ft. in these sections of the country. The expenditures will take place principally in the states of Minnesota, Iowa, Missouri, Mississippi, Wisconsin and Illinois.

Of all the projects the greatest is the St. Lawrence-Great Lakes project, providing a waterway and power development on this river, particularly in the neighborhood of New York state, and will require at least $175,000,000. It is temporarily held up because of the required negotiations with Canada and Great Britain to ratify the agreement appertaining to the matter and its details.

With the St. Lawrence project, the amount of money involved will be $375,000,000.

Power Development License Rescinded

THE FEDERAL POWER COMMISSION has officially announced the rescinding of the license to the State of Illinois for the power development of the Illinois waterway. The license was tendered last December but was not accepted. The Governor of the State of Illinois recently requested authority from the State legislature to make use of the license and proceed with the power development. The Legislature adjourned without granting the authority requested.

Recently the States of Michigan, Minnesota and Wisconsin entered protests with the Federal Power Commission, objecting to the terms of the proposed license to the State of Illinois, claiming that the power development would have water requirements in excess of that permitted under the recent decision of the United States Supreme Court with regard to the water diversion from the Great Lakes area. These states claim that the installation would require larger expenditures of money that might create equities in favor of Illinois that the courts might sustain in its behalf. Withholding of the license may not delay the actual construction of the project but will allow the protesting parties to be heard in full, and full consideration given to the objections.

Public Utilities Part in N.S.C. Program

AS A FEATURE of the National Safety Congress to be held at Chicago, Oct. 2-6, meetings are being devoted to accident prevention problems of the public utilities.

On Tuesday, October 3rd, the matter of employe training in safety will be discussed by Dr. Morris S. Viteles, Asst. Professor of Psychology, University of Pennsylvania, and Director of Personnel Research, Philadelphia Electric Co., Philadelphia. Professor S. N. Stevens, Northwestern University, and F. M. Pepper, General Plant Employment Superintendent, Illinois Bell Telephone Co., Chicago.

On Wednesday, Oct. 4, the physical plant from the safety standpoint will be analyzed by such outstanding men as W. R. Smith, Asst. Chief Engineer, United Engineers and Constructors, Inc., Newark, New Jersey; C. R. Beardsley, Asst. Superintendent of Distribution, Brooklyn Edison Co., Brooklyn, New York, and W. A. Buchanan, Appalachian Electric Power Co., Welch, West Virginia.

Federal Power Commission Policy

THE FEDERAL POWER COMMISSION, it has been learned on good authority, is outlining and building up a drastic and comprehensive plan for the control of power interests that are directly or indirectly within the possibility of Federal control. It is the purpose of the Commission to ask Congress for power to control all the holding companies and interests that are in any way interested in hydroelectric power plants on navigable waters or in the public forests or domains.

This power will control not only the erection and construction of the power plants, but also the issuance of securities for the project and that of the holding companies. The question has also arisen as to limiting the power of persons or concerns that are not of the United States, as in several cases such persons and concerns having control have come from other countries especially of British origin.

The power commission offers as an argument "that Federal intervention was inevitable in the swift working out of President Roosevelt's national recovery program, and that it would result in lower rates for many consumers." The commission is working on a "code" which it hopes to promulgate with the approval of the President. The purpose of the Code is not only one of "line of conduct" but also involves a matter of severe penalties if after being accepted, it is violated by any participant.

Mason-Neilan Regulator Co. Form

MASON-NEILAN REGULATOR CO., with offices at 1190 Adams St., Boston, Mass., has been formed by the consolidation of The Mason Regulator Co. of Boston and the Neilan

Co. Ltd. of Los Angeles, the latter a subsidiary of the Mason Co.

The engineering, manufacturing and sales departments of the two individual companies have been combined at the above address and F. Kenneth Morrison, formerly sales manager of The Mason Regulator Co. will continue in this same position for the consolidated company. Douglas H. Annin, chief engineer of the Neilan Co. will serve in a similar capacity in the new company.

This union brings under the Mason-Neilan trademark a complete line of automatic pressure regulating valves, liquid level controllers as well as compensated instruments for controlling pressures, temperatures, rates of flow, and combustion.

Stoker Manufacturers Annual Meeting

AT THE ANNUAL MEETING of the Stoker Manufacturers' Association held at the Palmer House, Chicago, July 24 and 25, the following officers were elected for the ensuing year: W. H. Rea, Detroit, President of the Detroit Stoker Co., President; J. R. Whitehead, Chicago, Manager Stoker Division and Research Department, Fairbanks Morse & Co., Vice-President; Harry H. Kurtz, Chicago, Branch Manager, Iron Fireman Manufacturing Co., Treasurer; and Marc G. Bluth, Chicago, Secretary.

Among the new members are Motorstoker Corporation, New York City; Holcomb & Hoke Manufacturing Co., Indianapolis; Link-Belt Co., Chicago; Fairbanks Morse & Co., Chicago; McClave-Brooks Co., Scranton, Penna.; Whiting Corporation, Harvey, Illinois; Whitty Manufacturing Co., Boston; Kol-Master Corporation, Oregon, Illinois; Columbus Metal Products, Inc., Columbus, Ohio; Cotta Transmission Company, Rockford, Illinois; Schwitzer-Cummins Co., Indianapolis, and Sinker-Davis Co., Indianapolis.

Other member companies are the American Engineering Co., Philadelphia; Brownell Co., Dayton, Ohio; Auburn Foundry, Inc., Auburn, Indiana; Combustioneer, Inc., Springfield, Ohio; Detroit Stoker Co., Detroit; Flynn & Emrich Co., Baltimore; Illinois Stoker Co., Alton, Illinois; Iron Fireman Manufacturing Co., Portland, Oregon; Laclede Stoker Co., St. Louis.

The Association adopted a National Industrial Recovery Code for the Stoker Industry, which has already been filed with the N. R. A. in Washington. The Stoker Code will comply with the requirements of the President's Reemployment Agreement and will conform to the National Industrial Recovery Act.

The next meeting of the Stoker Manufacturers' Association will be held this fall, the place and date to be determined later.

James W. Owens Heads National Weld Testing Bureau

JAMES W. OWENS has been appointed by the Pittsburgh Testing Laboratory, Pittsburgh, Pa., as its Consultant on Welding and Director of its new welding division, the National Weld Testing Bureau. The bureau's services cover: reports on welding processes; reports on weld specimens prior to construction; reports on weld specimens during construction; laboratory tests of weld specimens; investigation of welded products and structures; and investigation of special welding problems.

Mr. Owens' wide experience in the welding field covers a period of 15 yr., and includes close contact with technical societies and code making bodies of the A.W.S., the A.S.M.E., and the A.S.A. For the past three years he has been engaged in private consulting practice and as the Director of Engineering of the Welding Engineering and Research Corp. Prior to this, he was director of welding of the Newport News Shipbuilding & Dry Dock Co.; welding aide in the Bureau of Construction and Repair of the U. S. Navy; and a member of the Emergency Fleet Welding Committee during the World War.

Combustion Engineering Reorganized

ON AUGUST 1, 1933, Combustion Engineering Co., Inc., a newly organized company, took over the properties of International Combustion Engineering Corp. and affiliated companies recently sold by order of the Federal Court. The properties acquired include those of Combustion Engineering Corp., Hedges-Walsh-Weidner Co., Coshocton Iron Co. and Raymond Bros. Impact Pulverizer Co. In order to assure the best possible service to the company's customers, these properties will be operated under a single centralized management.

The new company will continue Combustion Engineering Corp.'s complete line of fuel burning, steam generating and related equipment which includes all types of stokers, pulverized fuel systems and boilers, as well as water-cooled furnaces, economizers, air preheaters, ash conveyors and hoppers. The same engineering personnel and manufacturing facilities will be continued by the new organization.

Officers of the new organization are: Frederic A. Schaff, President; Joseph V. Santry, Executive Vice-President; Robert M. Gates, Vice-President in Charge of Sales; Martens H. Isenberg, Vice-President in Charge of Production; John Van Brunt, Vice-President in Charge of Engineering; Harold H. Berry, Treasurer; George W. Grove, Secretary and Assistant Treasurer; George D. Ellis, Comptroller.

Death of F. W. Peek, Jr.

FRANK W. PEEK, JR., chief engineer of the Pittsfield, Mass., works of the General Electric Company and one of the company's specialists in high-voltage work, was killed July 26 when his automobile was struck by a train near Gascones, on the Gaspe peninsula of Canada. Mr. Peek lived about an hour after the crash; Mrs. Peek, who was with him on a vacation trip, was only slightly injured.

Mr. Peek was probably best known, both to the electrical engineering profession and the public, by his work in the field of lightning research. He had continued much of the general line of investigation begun in the early years of this century by the late Charles P. Steinmetz, under whom Mr. Peek worked for a period during the early part of his career, when he was a resident of Schenectady.

EQUIPMENT IN INITIAL INSTALLATION OF PURDUE UNIV. PLANT

(Continued from p. 375)

Boilers—Babcock & Wilcox Co., four, 3-pass, 5000-sq. ft., 210-lb. pressure, Stirling boilers, 2 of which are equipped with 547.6 sq. ft. convection superheaters to give 100 deg. superheat. Maximum capacity 30,700 lb. per hr., normal capacity 15,350 lb. per hr. Furnace volume 2110 cu. ft.

Stokers—American Engineering Co., four, 5 retort, 25 tuyere Taylor stokers with projected grate area of 102.9 ft. designed to burn 44 lb. of coal per hr. Each two stokers driven by 7 by 6 in. Troy vertical steam engine through jack shaft.

Forced Draft Fans—Green Fuel Economizer Co., two, 60,000-c.f.m., 7-in. of water gage forward curved fans. Driven by 120-hp., 1186-r.p.m., 200-lb. Terry non-condensing turbines.

Feedwater Heater—Cochrane Corp., one, metering deaerating type, capacity 120,000 lb. per hr. from 90 to 210 deg. F.

Water Softener—Cochrane Corp., hot process lime and soda ash softening system with a capacity of 3200-g.p.h.

Boiler Feed Pump—Worthington Pump & Mach. Corp., two, 4 in. 300-g.p.m., centrifugal boiler feed pumps driven by 80 hp., 200 lb. pressure Terry turbines at 2950 r.p.m.

Boiler Feed Pump—Dean Bros. Co., one, 150 g.p.m., 12 in. by 7 in. by 12 in., outside end part back pot valve boiler feed pump with a Hills-McCanna lubricator.

Ash Car .....Allen-Sherman-Hoff Co.
Ash Hoppers .....Allen-Sherman-Hoff Co.
Coal Scales ..... Standard
Water Columns. Reliance Gauge Column Co.

TURBINES AND AUXILIARIES

Turbo-Generators—General Electric Co., two, 5-stage, 200-lb. turbines driving 500 kw., 3600-r.p.m., 2300-v., 3-ph., 60-cycle 0.8-p.f. generators.

Condensers—Worthington Pump & Mach. Corp., two, 942-sq. ft., 2-pass surface condensers with ⅝-in. O.D. No. 14 B.w.g. Muntz metal tubes.

Circulating Pumps—Worthington Pump & Mach. Corp., two, 1070-g.p.m., 50-ft. head, 6-in. single stage centrifugal pumps driven at 1750-r.p.m. by General Electric 20-hp., 440-v. motors.

Hot Well Pumps—Worthington Pump & Mach. Corp., two, 27-g.p.m., 50-ft. head, 2-in., 2-stage centrifugal pumps driven by 3-hp., 440-v., 1160-r.p.m. General Electric motors.

Vacuum Pump—Worthington Pump & Mach. Corp., one, r.d.v. steam driven pump with Gardner governor.

Vacuum Pump—Worthington Pump & Mach. Corp., one, 2-stage steam jet ejector with inter and after cooler. Rated at 5-c.f.m. of free air at 2-in., operating with 130 lb. gage steam.

Atmospheric Exhaust Valves .....
.....Cochrane Corp.

Exciters—General Electric Co., two, 25-kw., 125-v., d.c. shunt wound generators, one driven by a 40-hp., 2200-v., 1800-r.p.m. motor, the other driven by a 25-kw., 200-lb. non-condensing 3600-r.p.m. Terry turbine.

Motor Generator Set—Fort Wayne Electric Works, one, 35-hp., 1200-r.p.m., 2200-v. motor, driving a 25-kw. 250-v., d.c. generator.

Switchboard.....General Electric Co.

Transformers—General Electric Co. and Westinghouse Electric & Mfg. Co.

INSTRUMENTS AND MISCELLANEOUS

Service Pumps—Worthington Pump & Mach. Corp., one, 150-g.p.m., 2-in., 2-stage centrifugal driven by a 15-hp., 440-v., 1750-r.p.m. General Electric induction motor; one 3-in., 300-g.p.m., 2-stage centrifugal pump driven by a 440-v., 20-hp., 1800-r.p.m., and one, 7½ by 7½ by 6 in. horizontal duplex steam pump with a Hills-McCanna lubricator.

Flow Meters .....Bailey Meter Co.
Locomotive Crane .....
.....Orton Crane & Shovel Co.
Oil Filter.....Burt Manufacturing Co.
Wayne Tank and Pump Co.
Pressure Gage.....
.....Consolidated Ashcroft Hancock Co.
.....Foxboro Co.
.....Jas. P. Marsh Co.
Steam Traps .....Swartwout Co.
Thermometers .....Foxboro Co.
Water Meter .....
.....Worthington Pump & Mach. Corp.
Traveling Crane (Generating Room).....
.....H. D. Conkey & Co.
Soot Blowers.....Vulcan Soot Blower Corp.

News From the Field

ERIE CITY IRON Works announces the appointment of Harry A. Pillen as district sales agent with offices at 622 Broadway, Cincinnati, Ohio.

THE SUPERHEATER COMPANY, New York, has appointed William T. Conlon, manager of its Industrial Department. In this capacity, Mr. Conlon will have charge of the design, manufacture and sale of Elesco superheaters for all types and makes of boilers for public utility and industrial power plants. The products of this department also include desuperheaters, resuperheaters, furnace water walls and miscellaneous heat exchange apparatus for power plants and process industries. Since November, 1929, Mr. Conlon has been serving in an executive sales capacity. Prior to joining The Superheater Company, he was associated with Utica Gas and Electric Company. Mr. Conlon is a graduate mechanical engineer from Purdue University, class of 1920.

THE ASHTON VALVE CO. of Boston, Mass., announce the appointment of C. B. Burgoyne, 408 North 23d St., Birmingham, Ala., as sales agent in Alabama.

WORTHINGTON PUMP AND MACHINERY CORP. announces the appointment of the Kroeschell Engineering Co., 2306 Knox Ave., Chicago, as the authorized dealer in the Chicago area for their refrigeration equipment.

TWO CHANGES in the official organization of the Allis-Chalmers Manufacturing Co., Milwaukee, have recently been announced. L. W. Grothaus, who has served as general representative in charge of the sales organization, is appointed as assistant to the president. His immediate duties will be to direct the company's interests in matters pertaining to the National Industrial Recovery Act as they relate to commercial problems.

Walter Geist, who is now appointed general representative, has been with the company since 1909, in the flour mill, saw mill, and power transmission division. He is the inventor of the Allis-Chalmers' "Texrope Drive," the multiple V-belt drive introduced by the company about 8 yr. ago.

THE DEATH RECENTLY occurred in Paris at the age of 86 years of M. Charles Bourdon. The deceased was for many years professor of steam engineering at the Ecole Centrale des Arts et Manufactures in Paris and the inventor of the well-known steam pressure gauge bearing his name.

THE YALE & TOWNE MANUFACTURING Co. announce the purchase of the real estate, machinery, tools, inventory, patents and goodwill of the Walker Vehicle Co. and the Automatic Transportation Co., of Chicago, makers of industrial electric trucks and commercial electric street vehicles, which lines supplement and complement the extensive lines already manufactured by the company. It will continue the manufacture and sale of the complete line of each company at 101 West 87th St., Chicago, retaining the present personnel with F. H. Tinsley in direct charge.

WESTINGHOUSE ELECTRIC & MFG. Co. announces the election of Winthrop W. Aldrich, President of the Chase National Bank, as a director of the company. In addition to the directorship to which he was elected, Mr. Aldrich is a director of the Chase National Bank, The American Telephone and Telegraph Company, American Express Company, Discount Corporation, Rockefeller Center, Inc., and other companies.

DETROIT STOKER Co. announces the appointment of William W. Moore as representative in the South with offices at 180 Westminster Drive N. E., Atlanta, Ga.

M. W. KELLOGG Co., New York City, announces that George Quint is now associated with the refractories division of the company as sales representative in Metropolitan New York.

THE PENNSYLVANIA ELECTRIC ASSN. will hold its 26th Annual Convention at Bedford Springs, Pa., on September 6, 7 and 8. The program is set up to feature a rather comprehensive presentation and discussion of industrial problems in which the manufacturers as well as utilities are interested.

For the Engineer's Library

STEAM, AIR AND GAS POWER. By W. H. Severns and Howard C. Degler. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York City. Size 6 by 9 in., cloth, 459 pp. Price, $4.00.

This is the second edition, entirely rewritten and reset to cover developments in the practice of power generation since the first edition. Such material as was considered obsolete or of least importance have been replaced with descriptions and illustrations of recent power plant equipment. The book, intended as a text book for students taking but a single course in heat engineering is unusually complete, describes briefly and clearly different type plants and representative equipment. Sufficient theory is given to make the action and operation of these machines and devices clear. Mathematical calculations involved are simple. Development of the book from simple power plants through modern steam power plant and the internal combustion engine plant is logical and easily followed.

REPORTS PREPARED by Committees of the N. E. L. A. prior to their dissolution have been printed by the Edison Electric Institute. They are now available and may be obtained from headquarters at 420 Lexington Ave., New York, N. Y. These reports are: Prime Movers Committee, A2 Station Piping, A3 Turbines, A4 Burning of Liquid and Gaseous Fuels, A5 Power Station Chemistry, A6 Pulverized Fuel, A7 Stoker Equipment and Furnaces; Underground Systems Committee, A9 A. C. Network Operation in 1931, A10 Cable Operation in 1932, A12 Fault Location Methods Used on Underground Cable Systems, A14 Current Carrying

Capacity of Impregnated Paper Insulated Cables; Power Systems Engineering Committee, A11 Load Area Development, A16 Load and Revenue Forecasting; Foreign Systems Coödination Committee, A13 Power System Wave Shape. Price of these reports range from $0.20 to $0.75 for members; $0.50 to $1.85 for non-members and $0.60 to $0.20 for foreign countries.

THE EDWARD VALVE AND MFG. CO. has just issued a booklet describing Evalloy, a stainless steel alloy, giving its characteristics and features.

NASH ENGINEERING CO. describes in bulletin No. 217 the Nash vacuum pumps and compressors, the Jennings line of vacuum heating pumps, including the new low pressure vapor turbine type, the Jennings non-submerged type of sump and sewage pumps, the Jennings no-valve pneumatic sewage ejectors, and the Jennings line of self-priming centrifugal pumps.

NORTHERN EQUIPMENT CO. has just issued booklet No. 133, illustrating and describing the Copes double control regulator, which feeds the boiler according to the rate of steam flow, with correction for water level changes.

D. W. HAERING & CO., INC., Chicago, Ill., has published a 16-page booklet on water treating which describes the application of H-O-H treatments to various water problems and explains in detail the cause and effect of many problems common to boiler and hot water equipment.

W. H. NICHOLSON & CO. has just issued bulletin No. 633 on its solenoid operated valve.

RILEY STOKER CORP., Worcester, Mass., has just issued a catalog on the new Jones side dump stoker.

VOLUME 3 in a series of booklets, "The Story of the Hoover (Boulder) Dam," has recently been published and is now being mailed by Ingersoll-Rand Co., New York, N. Y. It describes the railroad system, the gravel-treating and concrete-mixing plants, and the lining of the diversion tunnels with concrete. It also contains a general account of the Colorado

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has just issued a new four-page bulletin No. 1158 illustrating its line of bracket bearing alternating current generators, built in ratings from 30 to 1000 kv-a. These generators are suitable for coupled or belted service to high speed steam or internal combustion engines and for gearing to steam turbines.

B. F. STURTEVANT CO., Hyde Park, Boston, Mass., is distributing its Catalog No. 392 covering the complete line of Sturtevant Air Conditioning Units.

WESTINGHOUSE INSTRUMENT TRANSFORMERS are made the subject of Catalog 45, recently published by the Westinghouse Electric & Mfg. Co. Technical information, ratio and phase angle curves, descriptive information and prices are included in this publication.

LINK-BELT CO., Chicago, Ill., has just issued a souvenir book of the Link-Belt exhibit at A Century of Progress. The theme of this book is Serving Industry's Needs in the Handling of Materials and the Positive Transmission of Power by Link-Belt.

INDUSTRIAL X-RAY CORP., Los Angeles, Cal., describes Philips Metalix Portable Industrial X-Ray apparatus in a bulletin recently published. The book is virtually a treatise on the subject of industrial use of X-Ray equipment for detecting flaws in metals and perfecting manufacturing methods.

CONDENSER SERVICE & ENGINEERING CO., Hoboken, N. J., is distributing a recently published pamphlet entitled A Combined Service to the Entire Heat Exchange Field. The pamphlet describes the engineering, designing, manufacturing and maintenance equipment handled by this company.

APPLICATION of Diesel power to give lower cooling costs and showing examples of modernization of ice plants is covered in a new bulletin Lower Power Costs published by Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo.

SUPERIOR ENGINE CO., Springfield, Ohio, is distributing bulletin No. 126 which has just come from the press. This contains a description of the Superior portable Diesel power unit used extensively by contractors and others wishing a temporary power plant.

BACHARACH INDUSTRIAL INSTRUMENT CO., Pittsburgh, Pa., has just issued its bulletin 255 dealing with the Bacharach combustion gas analyzer, Model RZA. The bulletin describes the principle of the instrument and the essential features of construction and design.

BULLETIN No. 543 issued by Leeds & Northrup Co., Philadelphia, Pa., describes the company's U testing set which is a portable Wheatstone bridge especially designed for locating faults in communication circuits and convenient for making a variety of other tests on electrical equipment.

THE COOLING TOWER CO., New York, N. Y., is distributing Bulletin No. 330 dealing with atmospheric cooling towers and Bulletin No. 336 describing mechanical draft cooling towers made by this company. These bulletins are in loose-leaf form and contain information extremely helpful in designing and selecting cooling water equipment.

WESTINGHOUSE SURGE protection devices are made the subject of a 96-page catalog recently published by the Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa. In the catalog are listed new equipment including watthour meter protectors, transformer gaps and neutral arrestors, De-ion relief gaps, surge protection for rotation machines, and surge generators.

MORRIS MACHINE WORKS, Baldwinsville, N. Y., has published a new bulletin on side suction pumps. Various types of drives are illustrated, and complete rating tables are given for pumps driven by belt, motor and steam engine.

TYPE BA DE-ION power fuses are fully described in a new publication issued by the Westinghouse Electric and Manufacturing Company. This new fuse has high rupturing capacity, is low in cost, is of the dry type, can be refilled by the user, and may be refilled at one-half the usual cost. The unit is arranged for outdoor service but may be applied indoors without change. Three voltage ratings only are available, 7500, 15,000 and 23,000 v.

AMERICAN DISTRICT STEAM CO., North Tonawanda, N. Y. has just published Bulletin No. 415 containing complete information regarding construction, application, operation, special features, testing, maintenance and recommended installation methods for ADSCO Rotary Meters.

POOLE FOUNDRY & MACHINE CO. has just issued a new reduction gear catalog describing the Poole single, double and triple herringbone gear units.

INSTRUMENTS, valves and control equipment of the Defender Automatic Regulator Co., St. Louis, Mo., are illustrated and briefly described in the company's new Pocket Catalog No. 13. Regrinding chronometer valves and control equipment are described in the new Bulletin E.

LONG-HOUR-DUTY SPLIT-PHASE Motors are described in a new 6-page bulletin issued by the Wagner Electric Corporation, 6434 Plymouth Avenue, St. Louis, Mo. Illustrations of motor parts are surrounded by paragraphs describing every part, its function, construction, etc. When writing for this literature, ask for Part 5A of Bulletin 167.

CONVECTOFIN, the Built-In Heater manufactured by the Commodore Heaters Corp., New York City, is the subject of Bulletin No. 6 recently issued. Much new data is included, and the convection heating principle is stated simply and understandably.

FUEL VALUEGRAPH is the name given to an alinement chart designed and published by the Fuel Engineering Co. of New York, New York City. The chart is made up in pads on which rapid calculation of relative fuel values and fuel cost of steam can be made and permanently recorded by lines drawn across the chart. The factors entering into the calculations include costs of coal and oil, weights of coal and oil, heat values of fuels, combined efficiency obtained, the result of the calculations being the fuel cost of steam generated.

AMTHOR TESTING INSTRUMENT CO., INC., Brooklyn, N. Y., describes its humidity instruments in bulletin No. 108. These include direct-reading precision hygrometers, recorders, and other simple instruments used for determining accurately true air conditions.

W. H. NICHOLSON & CO., Wilkes-Barre, Pa., is distributing a new bulletin, No. 833, covering the "Nicholson" Industrial Steam Trap, the new feature being that it is suitable for all pressure up to 150 lb.

COMMERCIAL STANDARDS of Fuel Oils which became the standard of the industry May 1, 1933, is published by the U. S. Department of Commerce, Bureau of Standards, and is known as Commercial Standards CS-12-33. It can be obtained from the government printing office for 5 cents.

Power Plant Construction News

Ala., Muscle Shoals—Tennessee Valley Authority, Department of Interior Building, Washington, D. C., will have plans prepared at once for construction of steel tower transmission line from Wilson Dam, Muscle Shoals, to site of proposed new Cove Creek hydroelectric power plant on Clinch River, vicinity of Knoxville, Tenn., about 220 miles total. Work will be carried out in connection with $35,000,000 appropriation for Government hydroelectric power development at site noted. Lewellyn Evans, Muscle Shoals, is consulting electrical engineer.

Calif., Compton—Board of City Trustees, James H. Park, city manager, is considering construction of a municipal electric light and power plant in connection with municipal development program costing about $800,000. Proposed plant estimated to cost about $250,000 of fund noted. Also, plans to build a municipal gas plant to cost close to like amount.

Calif., Mojave—Mojave Smelting Co., Reno, Nev., plans installation of electrical and steam power equipment at proposed new smelting plant at mining properties at Mojave. Entire program will cost over $200,000.

Calif., Oakland — El Dorado Oil Works. Third Street and University Avenue, Berkeley, Calif., plans installation of electric power equipment in new cocoanut oil products plant at foot of Adeline Street, Oakland. Entire project will cost over $500,000. Ellison & Russell, Pacific Building, San Francisco, Calif., are engineers.

Calif., Vernon—Cereal Products Refining Co., 1008 Towne Avenue, Samuel A. Clarke, vice-president, plans installation of electric power equipment, pumping machinery, mechanical cooling and other equipment in new multi-unit brewing plant on 5-acre tract of land at Vernon. A boiler plant will be built. Entire project reported to cost over $200,000.

Colo., Denver—Bureau of Reclamation, Denver, will receive bids until Sept. 12 for two 3500 hp. horizontal shaft, double overhung, impulse type, hydraulic turbines, complete with hydraulic-operated shut-off valves, two oil pressure governors and complete auxiliary equipment; also, at same time for two 3000 kv-a., a.c. electric generators, complete with direct-connected main exciters and pilot exciters, for Boulder power plant, Boulder Canyon project, Nev., as per Specification 545.

Del., Stockley—Board of Trustees, State Institution for Feeble Minded, plans installation of pumping machinery and auxiliary mechanical equipment for new water system and sewage disposal plant. Appropriation of $162,020 authorized for this and other work.

D. C., Washington—Department of Interior has secured appropriation of $460,000 for construction of new steam-electric power plant at local Howard University, for electric light and power and heating service. Will soon have plans prepared.

Iowa, Grundy Center — At special election, citizens have authorized Common Council to arrange fund of $120,000 for construction of a municipal electric light and power plant. H. L. Cory Co., Baum Building, Omaha, Neb., is consulting engineer.

Kan., Washington—Common Council is considering preliminary plans for a new municipal electric light and power plant, estimated to cost about $85,000, with equipment. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Ky., Louisville — American Oak Leather Co., Kenner and Dalton Avenues, has plans for extensions and improvements in power plant. Cost over $30,000, with equipment. A. M. Kinney, Inc., Carew Tower, Cincinnati, Ohio, is consulting engineer.

Md., Beltsville—Department of Agriculture, Bureau of Land Industry, Washington, D. C., has secured appropriation of $98,100 for new cold storage and refrigerating plant at institution at Beltsville. Proposed to ask bids in near future.

Minn., St. Cloud—Common Council is considering construction of a municipal electric light and power plant, and estimates of cost will be made by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer.

Mo., Caruthersville—Common Council has authorized surveys and estimates of cost for a municipal electric light and power plant, and will arrange financing at early date. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

N. J., Newark — Hoffman Beverage Co., 402 Grove Street, plans installation of electric power equipment, pumping, conveying and other mechanical equipment in new multi-story brewing plant on adjoining site. Cost about $800,000. Plans being drawn. W. G. Hoffman is president.

N. J., Newark—Passaic Valley Sewerage Commission, 20 Branford Place, plans installation of pumping machinery and auxiliary mechanical equipment in connection with new sedimentation basin at sewerage disposal works on Newark meadows. A fund of more than $700,000 is being arranged. Engineering department will be in charge.

N. M., State College—Board of Trustees, University of New Mexico, State College, Henry Coors, president, is considering construction of isolated light and power plant for service at institution, and will secure estimates of cost.

N. Y., New York — Department of Justice, Bureau of Prisons, Washington, D. C., has secured appropriation of $25,000 for extensions and improvements in boiler plant at United States Detention Headquarters, New York.

N. C., Wilmington — Ethyl-Dow Chemical Co., a recently organized subsidiary of Dow Chemical Co., Midland, Mich., William H. Dow, president of both organizations, plans construction of power house, pumping plants and installation of electrical equipment for plant operation at new works at Kure Beach, near Wilmington, for production of bromine from seawater. Entire project will cost over $1,000,000.

N. D., Devils Lake—Common Council will have surveys and estimates of cost made for a municipal electric light and power plant. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo.. is consulting engineer.

Ohio, Cleveland—City Council is considering an ordinance providing fund of $2,000,000 for a proposed municipal electric light and power plant. Department of Public Service, City Hall, W. J. Kennedy, director, will be in charge.

Ohio, Cuyahoga Falls—Department of Public Service is arranging fund of about $300,000 for installation of equipment in municipal electric light and power plant, including generating units, boilers, pumps, transformer apparatus, switchboard and instruments. G. Murray is director.

Ohio, East Liverpool—City Council is considering preliminary plans for a municipal electric light and power plant, estimated to cost over $1,000,000, with equipment. Shover & Loftus, Oliver Building, Pittsburgh, Pa., are consulting engineers.

Ohio, Hamden — Village Council plans installation of pumping machinery and auxiliary mechanical equipment, valves, meters, etc., for new municipal waterworks. Entire project will cost about $57,000. H. E. Kimberly, 586 East Broad Street, Columbus, Ohio, is consulting engineer.

Ohio, Lockland—Fox Paper Co. has approved plans for construction of new steam power plant for paper mill service, estimated to cost over $80,000, with equipment. W. I. Barrows, 100 Edgewood Avenue, Dayton, Ohio, is consulting engineer.

Pa., Coraopolis — Borough Council plans early call for bids for installation of an electric distributing system for light and power service. Estimated cost about $70,000. Shover & Loftus, Oliver Building, Pittsburgh, Pa., are consulting engineers.

Texas, Goose Creek—Common Council has plans maturing for municipal electric light and power plant, to cost about $150,000, with equipment. David M. Duller, Second National Bank Building, Houston, Texas, consulting engineer.

Texas, Houston — Todd Shipyards Corporation, 25 Broadway, New York, N. Y., plans construction of steam power house, and installation of electrical equipment for plant service at new ship repair and drydocks on Houston Ship Channel, Houston. Entire project estimated to cost $1,100.000, and financing has been arranged. Frederick Harris is chief engineer.

Texas, San Antonio—Sabinas Brewery, Ltd., Sabinas, Coahuila, Mexico, plans construction of steam power plant at proposed new brewery at San Antonio, where site has been selected. Entire project reported to cost over $250,000.

Wash., Spokane — City Water Department plans construction of hydroelectric power plant to cost about $140,000, in connection with an expansion and improvement program in municipal waterworks, estimated to cost $1,000,000. Program will include installation of pumping machinery, pipe lines, etc.